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ABSTRACT

This document contains the Conference Agenda, followed by highlights from 42 Spotlight School systems across the country. The schools briefly share their experiences, evaluation techniques, and tell their success stories about the positive impacts technology is having on teaching and learning. Conference research materials are then presented. Papers include: "Perspectives on Technology and Education Research: Lessons from the Past and Present" (Margaret Honey, Katherine McMillan, and Fred Carrigg); "Convergent Analysis: A Method for Extracting the Value from Research Studies on Technology in Education" (Cathleen Norris, Jennifer Smolka, and Elliot Soloway); "Observing Classroom Processes in Project-Based Learning Using Multimedia: A Tool for Evaluators" (William R. Penuel, and Barbara Means); "The Technology/Content Dilemma" (Shelley Goldman, Karen Cole, and Christina Syer); "Technology: How Do We Know It Works?" (Eva L. Baker); "Documenting the Effects of Instructional Technology: A Fly-Over of Policy Questions" (Dale Mann); "The Cyberspace Regionalization Project: Simultaneously Bridging the Digital and Racial Divide" (Jonathan D. Becker); "New Directions in the Evaluation of the Effectiveness of Educational Technology (Walter F. Heinecke, Laura Blasi, Natalie Milman, and Lisa Washington); "Measurement Issues with Instructional and Home Learning Technologies" (Charol Shakeshaft); "The Idaho Technology Initiative: An Accountability Report to the Idaho Legislature on the Effects of Monies Spent through the Idaho Council for Technology in Learning" (State Division of Vocational Education, State Department of Education, Bureau of Technology Services); "West Virginia Story: Achievement Gains from a Statewide Comprehensive Instructional Technology Program" (Dale Mann, Charol Shakeshaft, Jonathan Becker, and Robert Kottkamp); "Testing on Computers: A Follow-Up Study Comparing Performance on Computer and on Paper" (Michael Russell); "Testing Writing on Computers: An Experiment Comparing Student Performance on Tests Conducted via Computer and via Paper-and-Pencil" (Michael Russell and Walt Haney); and "Critical Issues in Evaluating the Effectiveness of Technology" (Mary McNabb, Mark Hawkes, and Ullik Rouk). A short profile of U.S. Secretary of Education Richard W. Riley is then given. This is followed by an outline of the education and professional experience of Paulo Renato Souza, Minster of Brazil and a brief discussion on the implementation of the Brazil-US partnership in education. (AEF)

The Secretary's Conference on Educational Technology

Evaluating the Effectiveness of Technology

Washington Court Hotel
July 12th and 13th, 1999 -
Washington, D.C.

The Summary of the Conference is now in!

PDF In addition to basic text, the summary is also available in portable document format (PDF). In order to read PDF documents, you will need to have an Acrobat Reader installed on your computer. For information about how to download the Acrobat Reader free of charge, please visit the Adobe web site.

Please note that the PDF files may include forms and exhibits omitted from the text version.

Agenda
The Secretary's National Conference on Educational Technology: Evaluating the Effectiveness of Technology

July 12-13, 1999

July 12th - Monday
Day One

9:00 am-10:00 am

OPENING SESSION GRAND BALLROOM

Multi-media presentation — **"Virtual School Visit"**

Greetings — Linda Roberts, Director, Office of Educational Technology, U.S. Department of Education

Secretary's Address — Richard W. Riley, Secretary of Education, U.S. Department of Education — Introduction by Phil Bigler — 1998 National Teacher of the Year

Conference Orientation — Diane S. Reed, Technology Teacher in Residence, U.S. Department of Education

[redacted]

10:00 am-11:15 am	***PLENARY SESSIONS GRAND BALLROOM***

"Statewide Technology Evaluations"
Gordon Ambach Executive Director, Council of Chief State School Officers — Moderator

"West Virginia's Basic Skills / Computer Education Program: An Analysis of Student Achievement"
Henery Marockie, State Superintendent of Schools, West Virginia Department of Education
Lewis Solomon, Vice President, The Milken Exchange

"The Idaho Technology Initiative: An Accountability Report to the Idaho Legislature"
Mike Rush and Cliff Green, State Division of Professional Technical Studies, Idaho Department of Education

Question & Answer Session — Gordon Ambach

Closing Remarks — Senator Jay D. Rockefeller, WV

12:00 pm-1:30 pm	***LUNCHEON GRAND BALLROOM***

"Virtual School Visit"

Luncheon Address — Paulo Renato Souza, Minister of Education, Brazil — Introduction by Terry Peterson, Counsel to the Secretary, U.S. Department of Education

1:30 pm-3:30 pm	***SPOTLIGHT BREAKOUT/ WORKING SESSIONS***

"Setting the Context and identifying successes and barriers"

Spotlight Schools will be grouped with other schools and researcher/evaluators and facilitators to discuss findings from their evaluations. Schools will share their experiences, evaluation techniques, and tell their untold success stories about the positive impacts technology is having on teaching and learning. Participants will gain insight into what is happening in our schools across the country and discuss findings that have not been captured by the press or research community. There are 9 breakout groups (refer to notebook for rooms and groups). General invitees are encouraged to visit the breakouts, and participate in the discussions.

3:30 pm	***BREAK GRAND BALLROOM FOYER***

4:00 pm-5:30 pm

SPOTLIGHT BREAKOUT/WORKING SESSIONS II

"Identify learning criteria and accessing the impact of technology"
Schools and facilitators will go to the same breakout room as session

6:00 pm-7:30 pm

RECEPTION AND SPOTLIGHT SCHOOL SHOWCASE ATRIUM BALLROOM

Members of Congress invited. Spotlight Schools will be available to discuss their technology projects.

July 13th - Tuesday
Day Two

7:00 am-8:45 am

CONTINENTAL BREAKFAST ATRIUM BALLROOM

Spotlight School Showcase Continues

9:00 am

PLENARY SESSION GRAND BALLROOM

"What are we learning and what do we need to learn about technology effectiveness and impact?"

A panel discussion with the following leading researchers and evaluators:

Dale Mann, Interactive Inc. — Moderator

Eva Baker, Center for Research and Evaluation, CRESST/UCLA
Margaret Honey, EDC/Center for Research and Evaluation
Charol Shakeshaft, Interactive, Inc.
Elliott Soloway, University of Michigan

Question & Answer Session

9:45 am-10:30 am

BREAK

10:30 am-11:15 am

PLENARY SESSION — "The Media, the Stories, the Impact"

National, regional and local perspectives from members of the media and their experience covering educational technology issues.

Judy Salpeter, Editor-in-Chief
Technology & Learning Magazine
Andrew Trotter, Education Week
Alan Duke, Managing Editor CNN Student Bureau

Moderated by :
Dennis Gooler, Assistant Director, NCREL
Jayne James, Kansas Department of Education — Moderator

12:00 pm-1:30 pm

LUNCHEON GRAND BALLROOM

"Virtual School Visit"

Lucheon Speakers:
Congressman William F. Goodling, PA
Chairman of Education and Work Force Committee
Congressman Michael N. Castle, DE

1:30 pm-2:45 pm

SPOTLIGHT BREAKOUTS/WORKING SESSIONS II

"How to implement evaluative criteria"

Breakout sessions continued in same rooms

2:45 pm-3:00 pm

BREAK GRAND BALLROOM FOYER

3:00 pm-5:00 pm

CLOSING SESSION GRAND BALLROOM

"What did we find? What did we learn? Where do we go from here?"

Panelists:

Eva Baker, UCLA
David Dwyer, Consultant
Kathleen Fulton, University of Maryland,
Margaret Honey, Center for Technology and Children
Dale Mann, Interactive, Inc., Columbia University
Robert McNergney, University of Virginia

Lynn Schrum, University of Georgia, ISTE, President
Elliott Soloway, University of Michigan,
Walter Heinecke, University of Virginia

Linda G. Roberts, Director, Office of Educational Technology — Moderator

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Conference Agenda | Spotlight Schools | Spotlight School Contacts | Conference White Papers | Featured Speakers | Acknowledgements

UP Return to Conference Main Page

ED HOME

Page last updated on June 30, 1999 by [eid]

The Secretary's Conference on Educational Technology

Spotlight Schools

- Ainsworth Community Schools, NE
- Anderson County Schools, TN
- Aneth Community School, UT
- Blackfoot School District, ID
- Boston Public Schools, MA
- Bristol Warren Regional School District, RI
- Campton Elementary School, NH
- Carteret County Public Schools, NC
- Cherokee County School District, AL
- Cherry Creek Schools, CO
- Chicago Public Schools, IL
- Drew School District, MS
- East Detroit Public Schools, MI
- Edgewood Elementary School, GA
- Evergreen School District, WA
- Fabens School District, TX
- Gold Oak Union School District, CA
- Helena School District, MT
- Henrico County Public Schools, VA
- Hope Valley Elementary School, RI
- Hundred High School, WV
- Jennings School District, MO
- Kayenta Unified School District, AZ
- Kenton County Public Schools, KY
- Kuna School District, ID
- Lennox School District, CA
- Little Falls Community Schools, MN
- Mantua Elementary School, VA
- Montgomery County Public Schools, MD

▷ Conference Agenda

▷ Spotlight Schools

▷ Conference White Papers

▷ Featured Speakers

▷ Acknowledgements

- Middletown County Schools, OH
- Milwaukee Public Schools, WI
- New Haven Public Schools, CT
- Norman Public Schools, OK
- Ohio County Schools, WV
- Okaloosa School District, FL
- Oswego School District, NY
- Richland School District #1, SC
- Roy Municipal Schools, NM
- S.A.D. #4, ME
- Sherman Elementary School, WV
- South Harrison Community Schools, IN
- North High School, KS

Conference Agenda | Spotlight Schools | Conference White Papers | Featured Speakers | Acknowledgements

UP Return to Conference Main Page

ED HOME

Page last updated on July 1, 1999 by [eid]

Ainsworth Community Schools

Nebraska

Ainsworth, Nebraska, has been nicknamed the "Middle of Nowhere", and with good reason. Ainsworth lies in the sparsely populated Sandhills of north central Nebraska, approximately 200 miles from Omaha and 420 miles from Denver. A community of 1,870 members, Ainsworth serves as the county seat of Brown County, which has an area of 1,221 square miles and supports a total of population of 3,657. Ainsworth has a rural, agricultural economy, with major economic activities being farming, ranching, and cattle feeding. Brown County supports seven Class 1 "country" schools, as well as the Ainsworth Community Schools system.

Ainsworth Community Schools consist of Pleasant Hill Elementary, McAndrew Elementary, Ainsworth Middle, and Ainsworth High Schools. The school system serves 668 students, the vast majority of which are Caucasian. In order to provide students with educational experiences that include technology, the Ainsworth Community Schools incorporated technology as a component of its School Improvement Plan in 1994. A technology committee was appointed to enhance the use of technology to improve students' communication and critical thinking/problem solving skills. The district was aided in 1995 by an Excellence-in-Education Grant, a grant designed to expand the use of technology in the classroom. In 1996, Ainsworth Community Schools was selected to be a participant in the federal Challenge Grant. This grant's intention is to enhance curriculum integration with the use of technology. Through the Challenge Grant's Connection Project, Ainsworth has been able to provide its children with state-of-the-art technology instruction and equipment in spite of its geographical isolation.

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UP NEXT [Anderson County Schools]

Anderson County Schools

Tennessee

Anderson County Schools
HOMEPAGE

In virtually every state in the nation, reform efforts are dramatically raising expectations for students, and consequently, for teachers. In response to these reform initiatives, educators are being asked to master new skills and make necessary changes in their classrooms. To meet these new expectations, educators must deepen their content knowledge and acquire new methods of instruction. They need more time to work with colleagues, to critically analyze the new standards being suggested, and to revise curriculum. Educators need opportunities to develop, master and reflect on new approaches to working with students. All of these activities fall under the general heading of professional development.

A key lesson learned about school reform from the past decade is that far more time is necessary for staff learning and planning than is currently being made available. Staff development days, typically workshops, and brief meetings before, during, or after the school day when other responsibilities tug at the participants are grossly insufficient for the profound learning and planning which are essential to successful improvement in teaching and learning.

The importance and placement of professional activities will require the support of all stakeholders, including parents, students, and community members. Before redesigning professional development activities, it is important to understand the research on best practices in professional development. Research clearly defines the following assumptions:

Ongoing professional development is required if it is to result in significant change. School change is the result of both individual and organizational development. The goal of professional development is to support the inquiry into the study teaching and learning. Teachers learn as a result of training, practice, and feedback, as well as individual reflection and group inquiry into their practice. Professional development is essential to school development. Professional development should be primarily school focused and embedded in the job.

Professional development programs based on these beliefs are quite different from those based on traditional assumptions. While district wide workshops still will be appropriate on occasion, most professional development should be school based. Educators should attend hands on workshops and conferences, and be involved in a variety of ongoing, job embedded learning activities, such as study groups, action research, peer coaching, curriculum development, and case discussions.

In Anderson County In Anderson County, the Office of Technology developed a system wide technology plan, which allowed school sites to develop their technology plans. After evaluating school, teacher, and student needs in the school technology plans, professional development activities can be developed.

System Technology Plan (Handout #1, Sections 1Ä3) Because KÄ12 education has traditionally been restricted by limited budget funds, it was imperative that whatever funds were expended on technology be made to serve the most students possible. This has forced most purchases to focus on meeting today's needs only. Unfortunately, as changes in technology come more rapidly and software becomes more demanding, technology bought with only today in mind become obsolete very quickly.
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[Ainsworth Community Schools] PREV UP NEXT [Aneth Community School]

Aneth Community School

Bureau of Indian Affairs
Utah

Aneth Community School is located in a remote region of Southeastern Utah near the Four Corner National Monument. The community is within the boundaries of the Navajo Nation Reservation. The School was built is 1965 with one education building, two dormitory buildings, one kitchen/dining building and a small maintenance building. In the tradition of the time, multiple single family and apartment style dwellings were built adjacent to the school facility. Over the years there have been few changes except for the change from K-8 to K-6 and the demolition of one of the dormitory buildings. Until the Summer of 1995 technology at the school consisted of a few computers scattered around in classrooms and offices and a modest number of telephones in administrative offices.

In the Summer of 1995 Aneth Community School was included in a Star Schools Grant as a minor partner for which a new computer lab and a distance learning receive site was installed on site. The key feature of this installation was the microwave tower that provided for full motion video, voice and data to come and go from the school. The two way video/audio connection was used from the start, but, the data connection was not utilized until later. This partnership had shown the need for more technology at the site and the local administration began working on a plan to write a Technology Literacy Challenge Fund Grant and dedicate base funding to the furtherance of technology. In the Summer of 1997 the Office of Indian Education Programs awarded a five year grant to Aneth Community School. That same year the Principal decided to make a large one time infusion of resources into technology.

The Summer and Fall of 1997 was a frenetic time at Aneth Community School. First to come was an extensive wiring project which entailed data, voice and video cabling being pulled in all the buildings on campus and being tied together by a fiber optic backbone. Shortly after the new year we received forty-four new computers and a new server. One new computer was put into every classroom for teacher use along with administrative offices. Additionally, computer mini-labs were established in the kindergarten to third grade and color printers were placed in every classroom. Through the Spring and Summer of 1998 we selected 27 inch televisions with internal scan converters and placed them into each classroom also.

With the campus cabled and computers, printers and display devices into each classroom attention was focused on campus communications and faculty development. Major projects in the Summer of 1998 included the installation of a video head end system, a telephone system complete with phones in every classroom, voice mail and a digital satellite downlink which brought eight bachelors and four masters degrees to Aneth via distance learning technologies.

All along we have kept an eye on how quickly the faculty and staff will assimilate new hardware and software. Ample opportunities have been provided in small clinics on Fridays and during week long session held once or twice a year. Attention has always been placed upon creating an atmosphere for success by the learner.

The future looks bright as we head into our third year of funding. The foundation is solid as we look to turn the corner and attempt to create an environment where computers and pencils are equal in their appropriate tasks and classroom teachers become coaches and facilitators of all the learning tools at their command. Students, parents, faculty, school board members and administrators all agree that there is a special excitement at Aneth Community School that has not been here for along time.

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[Anderson County Schools] PREV UP NEXT [Blackfoot School District]

Blackfoot School District

Idaho

Blackfoot School District
HOMEPAGE

Over the past five years Blackfoot School District has placed a stronger emphasis on the integration of technology into the classroom to positively impact student achievement. Assistance from the Idaho State Department of Education in conjunction with Federal and a variety of grant initiatives (Technology Innovation Challenge Grant, Technology Literacy Challenge Fund, Albertsons Waterford Initiative and ICTL Funds) have enabled the district to move toward implementation of the District's Technology Plan.

The Blackfoot School District Technology Plan is based upon a comprehensive needs analysis that addresses student needs, teacher needs, curriculum integration, and the availability of technology to accomplish stated goals.

Technology Action Plan

In an effort to positively impact student achievement by leveraging the potential of technology, a three-year, educationally driven plan has been developed with both intermediate and long term goals established. Based on research in educational technology, the plan addresses the need to consider professional development, the availability of technology and curriculum integration. The anticipated academic outcomes are based on a district academic audit, teacher and administrative perceived needs, academic testing and performance indicators, and parental input. The identified academic areas of focus are language arts and math. It is recognized that various elements must be in place to achieve the desired outcome of increased student achievement. These elements include:

Professional Development
Assisting teachers to gain the necessary skills to optimize technology. The effective implementation of technology in the classroom requires not only the technical skills to operate the technology, but changes in classroom management and organization must also take place. This requires an investment in time and training (Idaho State Goals 1, and 3). In the process, teachers will move toward the State requirements for technology certification.

Administrative training which promotes the effective integration, evaluation and administrative uses of technology (Idaho State Goals 1, 2 and 3).

Availability of Technology
Provide teachers and administrators with the tools to be successful. To attain this goal, a three-year plan has been developed which places computers in the classrooms in accordance with the State suggested ratio and research of 5 computers per classroom (State Goal 2, 5 and 1). In order to impact student achievements they must have access and adequate time on task. It is not fiscally possible to equip all

classrooms at one time therefore a staggered schedule which enables the disbursement of computers by grade level starting at the third grade and progressing through the twelfth grade has been established. This promotes adequate access to enable time on task and the ability to train teachers on a district-wide basis by grade level to have the skills and knowledge to benefit from technology. It is the individual school's responsibility to provide printers, consumables and Internet access at the classroom level through the use of building funds. Internet connectivity is available to academic classrooms in all buildings except the sixth grade center where there is currently a lab online and it is anticipated that individual rooms will be connected by the end of the 1998-1999 school year. Building maintenance will provide the remodeling, upkeep or physical requirements to accommodate the acquisition and maintenance of technology.

Provide technical support structures minimizing frustration and promoting effective use. The District is expanding their support through the use of in- district support and student training (State Goals 2, 5,7 and 8).

Curriculum Integration
Purchase and implementation of well researched software addressing the identified academic outcomes (State Goals 1, and 4). Supportive training which promotes the effective use will be provided.

National Standards for Technology in Teacher Preparation have been used as a guideline in developing effective staff development. Involvement of teachers in the integration of technology into the classroom frequently involves incentives. The District is providing inservice aimed at using technology effectively to enhance academic achievement and promote the effective administration of schools at no cost to participants. Necessary tools to be successful, (training, software and equipment) will be made available. In addition, release time is available for a wide variety of training opportunities.
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[Aneth Community School] PREV UP NEXT [Boston Public Schools]

Boston Public Schools

Massachusetts

Boston Public Schools
HOMEPAGE

Boston Public Schools (BPS) has received many awards for its leadership role in technology among large urban cities. Boston's plan LINC Boston (Learning and Information Network for the Community) is a comprehensive five year plan to address all of the key elements involved in implementing a substantive technology program in our schools. As of Spring 1999, in the third year of the plan, Boston can attest to the following accomplishments and immediate goals.

Networked Schools

Every one of Boston's 130 schools has a "starter network" (computer lab, library, principal's office, and 4-8 classrooms) connected to a wide area network based at Court Street, our central administrative office. Eleven schools are completely networked, with plans to complete the networking of all schools by 2002. Boston is the first major urban school district in the country to have networks and high-speed Internet access throughout every school.

Hardware and Software

In June 1995, Boston had a 1:63 computer student ratio for new computers. By June 1999, we will have installed 10,500 additional state of the art computers, bringing Boston to a 1:6 computer to student ratio. This accomplishment puts Boston well on the way to reaching the goal of one computer for every four students and a computer for each teacher, a commitment made by Mayor Menino in his State of the City Address in January 1996. All computers come "loaded" with software; Microsoft Office on all machines, and in addition, ClarisWorks, KidPix, and HyperStudio on all elementary and middle school equipment. Each school also receives a budget to purchase additional curriculum software.

Assistive Technology

Boston Public Schools, supported by funding from city, state and federal funds, has made a major commitment to providing computers and appropriate assistive technology to all special needs classrooms by 2002, as teachers participate in professional development to understand how to use these technologies to support student learning.

Professional Development

Boston has developed Technology Competencies to be achieved by all staff. These competencies, based on those recognized by the International Society for Technology in Education (ISTE), and supported by the Boston Teachers Union, have five levels of proficiency. At each level, BPS offers free on-site courses to teachers, principals, and other staff to help them achieve those competencies. In addition, teachers are awarded computers for their classrooms, once they have completed competencies at each level, and have been "coached" by one of their colleagues to produce technology based materials for their classrooms. By June 1999, 2,000 teachers (40% of all Boston teachers) will have received their first computer and printer, recognizing their development of "productivity tools" for their classrooms. 400 teachers will have participated in curriculum integration projects and received additional classroom computers. Beginning in 1999, new teachers must document technology competency at the Novice level or participate in summer workshops prior to beginning teaching in September. New teachers will be eligible to participate in coaching during their first year of teaching and to receive technology for their classrooms.

Student Competencies

In September 1998, a team of Lead Teachers representing all grade levels and including subject area teachers, bilingual, SPED, and computer instructors, began to work to develop a set of Student Technology Competencies. (Being sent with Technology Plan) They based their work on the standards recommended and recognized nationally by the International Society for Technology in Education. In presentations to groups of teachers, principals, parents, and the Leadership Team, the Competencies have been well received. Teachers and principals alike appreciate the fact that clear and consistent expectations are established for students and teachers at all grade levels and that the Competencies are directly connected to the City-wide Learning Standards.

It is important to note that these Competencies cover the use of technology as a tool to enhance learning in all subject areas. Technology education, defined as a study of the machinery that each generation develops to make society's work easier and more productive, is covered both at the state level and in Boston, as part of the Science curriculum.

Curriculum Integration

Boston Public Schools, supported by grants from the federal and state governments, as well as by IBM, is developing web-based resources to support the dissemination of exemplary curriculum materials which support Boston's Citywide Learning Standards, as well as on-line rubrics to support the assessment of student work. Hundreds of teachers participate in technology based curriculum workshops and coaching to share the development of best teaching practices.

Libraries

All Boston Public High School libraries, as well as 10 elementary and middle school libraries are automated, in a unique partnership with the Boston Public Library. All students in these schools have access to all of the resources of the Boston Public Library, directly from their schools. They use Boston Public Library cards to check out books at their own schools, as well as being able to look up books at every branch library, and reserve books and have them delivered right to their schools. This partnership between school and public libraries is the first of its kind in the country.

Support

The greatest challenge for all school systems developing technology programs is providing adequate support for the technology. To address this concern, Boston has worked on several fronts, including the development of a remote management system for all its networks, and implementation of a sophisticated Help Desk system which responds to many problems over the phone and deploys teams of technicians to resolve others. Boston anticipates that a major source of support for its technology will be its own BPS students. Though partnerships with Microsoft, 3Com and Cisco and other technology companies, Boston's Offices of School-to-Career and Instructional Technology have developed courses and apprenticeships for students ranging from A+ computer repair to networking, and systems operation. After school and during vacations, students work as apprentices to BPS technicians, supporting the technology in schools. BPS is developing a 13th and 14th year program in collaboration with CityYear and Americorps for our graduates to continue their work as stipended interns in the schools, and at the same time continuing their technical training.

Partnerships

Boston Public Schools has received tremendous support for its technology programs. The LINC Plan has raised more than $38.75 million dollars, including $15.75 from private partners, and $23 million in grants. Major business partners include 3Com, Microsoft, HiQ, Intel, Bell Atlantic, Boston Edison, and more than 100 other companies.

Awards:

The LINC Boston Plan has won the following awards:

- National League of Cities 1998 Innovations Award
- Massachusetts Software Council 1998 Innovator Award
- John Hancock 1998 Innovations in Education Award
- Macy 1996 Leading Boston into the 21st Century Award
- Nominee for Smithsonian Institution 1999 Innovation Award

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[Blackfoot School District] PREV UP NEXT [Bristol Warren Regional School District]

Bristol Warren Regional School District

Rhode Island

Bristol Warren Regional School District initiated the implementation of a district wide technology system necessary to improve teaching and learning in 1997. This initiative also supports professional development, changes school culture and addresses individual student needs. The district technology plan includes the systematic purchase of hardware and software. Ongoing professional development is provided for our staff. The district attempts to adequately budget for the resources necessary to sustain district technology initiatives. Kickemuit Middle School, through an extensive renovation project, has become our first state of the art technology enhanced learning environment.

Bristol Warren Regional School District is implementing a wide area network that will provide the district with technology systems necessary to achieve the reforms listed above. We began this effort in the summer of 1997 and plan to have the system fully operational by fall 1999. Implementing the district wide area network has required wiring each building, installing hardware such as NT servers, purchasing district software and creating a district frame relay cloud with T1 Internet access.

To ensure the success of our technology implementation, we have planned a variety of professional development opportunities for teachers. This professional development is a combination of state and local efforts. Bristol Warren Regional School District provides workshops for all teachers. These workshop focus on specific technology skills as well as curriculum integration.

Fifty teachers in Bristol Warren have benefited from the RI Foundation Teachers in Technology Initiative (RITTI). These teachers have received a laptop computer and two weeks of technology training. Upon returning to the district, a number of them with the proper district support, have significantly improved the technology integration in their classroom and professional endeavors. An additional thirty-two teachers will participate in the RITTI program this summer.

The Kickemuit Middle School renovation provided the opportunity to integrate technology into all aspects of the middle school. The school has an extensive network with multiple high speed Internet connections in every classroom. The multimedia library is automated and includes numerous student workstations. Every teacher has a desktop workstation with projection capabilities. The school also includes three computer labs - a teaching lab, a sending lab and a writing lab.

Professional development at Kickemuit is provided using various training models. Every teacher attended a basic training workshop prior to implementation in 1998. One of the most successful models presently used is "just-in-time" training sessions. The school technology facilitator is responsible for providing ongoing technology curriculum integration training opportunities and workshops. Team planning periods focus on specific training and curriculum needs. Site-based workshops focus on identified technology needs of the school. Support is also provided electronically through e-mail, listservs and web pages.

Using Kickemuit Middle School as a model for educational technology, Bristol Warren Regional School District's goal is to expand technology in all schools throughout the district. We look forward to improving student learning through increased technology integration district-wide.
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[Boston Public Schools] PREV UP NEXT [Campton Elementary School]

Campton Elementary School

New Hampshire

Our technology implementation plan provides the vehicle to revolutionize the way we teach and the way students learn. Skillful use of technology supports the development of process skills such as flexibility, adaptability, critical thinking, problem solving, and collaboration which are essential to success in our rapidly changing information age. The student and faculty at Campton Elementary School are able to access information, manipulate data, synthesize concepts and creatively express ideas using video, text, and audio media. Information technology provides a depth richness of instructional approaches to reach student of all learning modalities. It allows educators to better serve the diverse learning styles of our students and educate them through a spectrum of multiple intelligences. The integration of technology across the curriculum provides access to otherwise unattainable information and better prepares our students for a life of learning.

Our curriculum is ambitious. Successful implementation of our information technology vision requires a tremendous commitment and, because we truly believe in maintaining a high quality educational program, we provide an ongoing monthly program of inservice training. Therefore, each student, teacher, staff member, and administrator much regular access to the technologies that enables him/her to keep up-to-date with technology.

It is our school vision that all members of our community will access, manipulate, integrate and communicate information within, and beyond, the school setting. Electronic links (school-wide networks, community bulletin boards, and global networks) should be easily accessible and easy to use in order to facilitate communication between and among such groups as: students, teachers, administrators, parents, universities, public libraries, states and federal agencies, businesses, and community groups. Information technology and curriculum are intrinsically linked and ever changing. This plan is not meant to be static, rather it is designed as a working plan, and our goals will necessarily change as technology changes, curriculum evolves, and as we move into a technology based society.

Our Campton Community Technology Program's goal is to generate and strengthen parent and community involvement, allowing the school community to move from isolated classrooms and families to one connected, active, collaborative learning community. Parents and community members participate in several workshops to learn how technology can be a vital part of their lives. Additionally, parents can check the Internet for their student's homework at HomeworkNow Our greatest educational success will come when information technology becomes an integral part of all areas our curriculum and an everyday aspect of the students' learning process.

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[Bristol Warren Regional School District] PREV UP NEXT [Carteret County Public Schools]

Carteret County Public Schools

North Carolina

Carteret County Public Schools
HOMEPAGE

Carteret County is a rural, fairly isolated County on the coast of North Carolina. The Public School System is composed of 15 schools with a population of 8,500 students.

The Technology Plan for Carteret County School System forms the foundation and the guide for all the roles of technology in the District. Support for the Plan has been widespread and effective, from top-level administration, faculty, staff, students, and community. Without this foundation of planning and this platform of support the level of technology integration now evident in Carteret County Schools would not have occurred.

In review, the District has met or exceeded expectations in most areas and progress continues towards stated goals. Because of this progress the 1998 revision of our Technology Plan focuses more on the seamless integration of technology into the learning environment which is our ultimate goal.

Earlier iterations of the District's Technology Plan emphasized the acquisition of hardware and the use of software as a supplement and enrichment for the traditional classroom setting. The current Plan focuses on the evolution towards integration of technology into a student-centered, project-based learning environment. In the 1998 revision telecommunication technologies, web publishing and wide area networking are more in evidence.

Accomplishments over the last three years include:

- progressive inroads into integration of technology for instruction and learning
- major progress towards the minimum standard of equipment in all classrooms
- campus networks that meet or exceed State standards in all schools and Central Office-- installed and functioning
- all teachers participating in technology staff development with the majority having completed Parts I and II as defined in the technology staff development outline
- positive beginning to a new model for technology staff development that assists in moving schools towards a student centered, constructivist learning environment, which meshes with the overarching goals of the School System
- additions to the technology support staff-- eight instructional technology coordinators, six technical support technicians
- implementation of wide area network through State Telecommunication Services increased School System and public support for technology in order to meet the needs of students living in an Information Age

- institution of evaluation strategies that assess progress in meeting the goals and objectives of the Technology Plan.

These things have been funded or made possible through:

- passage of a local 6.2 million dollar bond referendum for technology
- State Technology funding
- Title VI funds
- Technology Literacy Challenge Grant funds
- Universal Service Rate (e-rate) discounts
- other local funds that include additional money for media centers
- a portion of local and State instructional funds
- local school fund raisers
- contributing partners and businesses

It is anticipated that the coming years will see the same or increased progress towards the goals, objectives and strategies of the School System's Technology Plan.
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[Campton Elementary School] PREV UP NEXT [Cherokee County School District]

Cherokee County School District

Alabama

Cherokee County can best be described as a rural agricultural community whose solid economic environment is comprised of fertile lands and an abundant water supply. Agriculture is the county's largest industry, involving not only row crops but also new agri-businesses such as seed production and ornamental plants. Weiss Lake makes tourism a vital part of the local economy. Little River Canyon National Preserve, historical sites, points-of-interest, and town festivals compliment the county's appeal as an attractive place to visit.

The county school system offers the more than 3500 students of Cherokee County extensive learning opportunities, including the traditional curriculum, fine arts, vocational training, and technology. Furthermore, with the many athletic programs and extra curricular activities at each school, students are assured a well-rounded, quality education.

Our commitment to a quality technology program has been the single "thread" that runs through all areas of the curriculum. Our technology program had its beginnings some seven years ago when our local telephone company (Peoples Telephone Company) asked if we would like to have dial-up access to the Internet supplied to the schools and also be responsible for managing the server. This was a true learning experience for both parties. They succeeded as an Internet Service Provider, and the dial-up Internet access opened up the world to our students and teachers. Since that first connection, technology has been a main focus in our curriculum. Three years ago the Cherokee County Board of Education voted to provide the matching funds necessary to install a LAN at each school and tie everything back to a central location so that information could be shared from school to school and with the Central Office. The design, installation, and maintenance of the LAN's and WAN would be based on the concept that we would have to rely on ourselves for almost everything. We were operating on a "shoe-string" budget and could not afford the luxury of hiring outside consultants or contractors. In a four month period of time, with hundreds of hours of volunteered time eight students and two teachers wired every school in Cherokee County. Over 15 miles of Category 5 wire was installed, along with the hundreds of connectors used to terminate the wire ends. The eight student technology team wired each equipment rack, installed the patch panels, hubs, switches, Novell servers, and connected all computers at each school to the newly established LAN. The Cherokee County WAN consists of HDSL (786 kbs) connections at six sites and the four remote schools are connected to the WAN via 10 Mb wireless spread spectrum links. Wireless connectivity was the only affordable option and has proved to be as strong a telecommunication link as the conventional sites, only less expensive. With the help of Trillion Digital Communications, we became the first school system in Alabama to have a wireless WAN connecting schools. This hybrid network is the backbone of technology in Cherokee County. It is unique and one of a kind that serves the students and teachers well. Internet access, administrative data transfers, and e-mail are the main functions of the network at this time. In August 1999, distance learning becomes a reality in our rural school system. Jacksonville State University and the Cherokee County School System will partner a dual enrollment project that will allow students and teachers to take college courses via a video conferencing system between JSU (some 45 miles south of Cherokee County) and Cherokee County.

Our newest partner, Lucent Technologies, will assist us in taking our technology plan to our ultimate goal. It has always been our plan to eventually bring video, data, and, audio to the desktop. With a very limited budget we knew that this would be something that would be years down the road before we could obtain this goal. With Lucent Technologies newest products, MMCX and Virtual Lecture Hall, we will be able to meet our goal of desktop video conferencing and even surpass it. We will now be able to share resources from all over the county, as well as utilizing resources from neighboring systems. We will now be able to offer advanced courses to small groups of students at all our school sites from a central location. Collaboration and sharing of ideas and best practices between teachers, students, administrators can now be easily facilitated over our WAN and across links to distant sites.

We are exactly where we wanted to be, only about two years ahead of schedule thanks to the help, support, and expertise of Lucent Technologies, Trillion Digital Communication, Peoples Telephone Company and a great deal of local effort and support.
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[Carteret County Public Schools] PREV UP NEXT [Cherry Creek Schools]

Cherry Creek Schools

Colorado

Cherry Creek Schools
HOMEPAGE

The Cherry Creek School District is changing the teaching and learning environment for teachers and students by applying effective instructional practices, technology uses, and technological infrastructure to directly target and accomplish our student achievement objectives. We began the process by developing a comprehensive five-year district technology plan which aims best practices in technology use directly at enhancing student achievement. The goals of our program are designed to ensure that students and teachers have modern, powerful technology that will help them apply skills necessary to thrive in today's digital age. We expect teachers to become developers of technology integrated curriculum and students to become critical thinkers, problem solvers, and life-long learners. Our goals include:

- Using technology to enhance student achievement.
- Engaging teachers in ongoing professional development focused on student achievement through technology use.
- Establishing an electronic culture within the district.
- Evaluating technology use in the district to ensure its application to enhance student achievement.

The primary focus of our program is to put a critical mass of technology in classrooms where students can use it to apply critical thinking and problem solving skills, along with basic skills to meet the District student achievement objectives. To accomplish this, we use a solutions approach to purchase new technology. Solutions consist of hardware, software, professional development, and model curriculum and have evidence of being effective for student achievement. Schools write and evaluate annual technology plans, which focus on how technology can meet the building's student achievement goals.

Professional development is the key to ensuring that technology is integrated with the curriculum. We consistently spend one third of our annual technology budget on professional development. The most significant piece of our professional development comes from site-based Student Achievement Specialists (SAS). The SAS is a certified classroom teacher who understands school reform, instruction, curriculum, and how technology can enhance learning. The SAS is provided with a half to a full day of release time daily to conduct professional development in their buildings. The District and the school share the funding for the SAS position. To foster and guide these professional development efforts in the buildings, the District provides four Teaching, Learning, and Technology Specialists (TLTS) to support the schools. The TLTS provides support and training for the building SAS and works under the direction of the Director of Technology, Stephen Cowdrey.

The advances made in instruction could not be accomplished without the infrastructure and technical support provided at the district level. We have installed wide area, local area, and video networks in every school. Every classroom has a high-speed connection to the Internet and all students and staff have e-mail addresses provided by the District. An intranet is in place to store, share and quickly disseminate information and resources. We have district level technical support services which, at the least, provides for a half day of onsite technical support at elementary schools and a full day of onsite technical support at middle and high schools each week.

The success of our program lies in ongoing per pupil funding. The school programs are funded through per pupil capital reserve money and decentralized budgets. The money for the infrastructure was funded through a $5 million bond election. We recently passed a budget election of which $.8 million annually is designated for technology. This allows us to be completely funded from ongoing sources.

We are currently in the fourth year of our five-year technology plan and we will write a new plan in the fall. Our ongoing evaluation of our first technology plan demonstrates we are successful. Our SAT and ITBS scores have increased over the course of our technology implementation and are at an all time high in the District. We are also measuring ourselves against the StaR chart from the CEO Forum, the National Educational Technology Standards, and the Professional Development Indicators and Seven Dimensions of the Milken Exchange. We are making considerable progress on every one of these measures. We were a site visit district for the National School Boards Association (NSBA) last year, we were recently featured by Apple Computer in a nationwide satellite broadcast for our professional development program, and we will be featured in a video salute at this year's NSBA/ Institute for the Transfer of Technology in Education's (ITTE) Technology + Learning Conference.

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[Cherokee County School District] PREV UP NEXT [Chicago Public Schools]

Chicago Public Schools

Illinois

Chicago Public Schools
HOMEPAGE

The City of Chicago has a broad and diverse population of nearly three million people and is rich in ethnic communities and neighborhoods. The city has a history of cultural diversity which is reflected through its many cultural attractions, events, and community activities. There are 77 neighborhoods, over 40 museums, more than 150 theaters, three of the world's tallest buildings, and the world's largest public library. Based on the 1990 Census of Population and Housing, Bureau of the Census, U.S. Department of Commerce, Chicago has over one million households and accounts for nearly one-fourth of the entire population of Illinois.

According to the May/June 1996 Journal of Business Strategy, Chicago ranked second in overall business climate when compared to nine other large and mid-sized American cities. This was based on a composite index which included: the number of international air destinations; cost of living; diversity of worker skills; gross domestic product (GDP); population; number of Fortune 500-ranked global headquarters; and employment-unemployment rates. The Chicago area has the third largest labor pool in the country ("Geographic Profile of Employment and Unemployment," December 1995, Bureau of Labor Statistics).

The business community represents a large population. Revenue paid to the state generally is returned through various programs and initiatives. Employees provide a tax base since they reside in the City. CPS is the largest school district in the State of Illinois, has the ability to levy taxes as a taxing body within Cook County, and may sell bonds. It is a part of city government and the City of Chicago's economic base. The City has a MA rating in terms of its own ability to sell bonds. CPS's credit rating is Baa1, A-, and BBB+ from Moody's, S&P and Fitch, respectively. However, a critical revenue factor that impacts schools -- 85% of CPS students receive free and reduced lunches, which means the residential tax base is substantially low.

In 1994, the City of Chicago was designated as one of six urban Empowerment Zones (EZ) by the U.S. Department of Housing and Urban Development (HUD). Chicago's EZ areas are the near West Side, Pilsen/Little Village and the near South Side. Benefits include: $100 million in Social Service Block Grant (SSBG) funding, tax credits for businesses located in the EZ who employ residents of those communities; accelerated depreciation for capital equipment purchases for EZ businesses; consideration for waiver from federal regulation; and new tax-exempt EZ bonds. EZ designation also generates priority consideration for federal grants (1990 Census of Population and Housing).

CPS comprises the third largest school system in the United States. It's nearly 600 schools, spread across 228.5 square miles and service over 424,000 students (CPS Fact Sheet, May 1997 - 1996-97 "Student Enrollment"). The racial breakdown of the student population is as follows:

- 54.5% African American
- 31.3% Hispanic
- 10.8% Caucasian
- 3.2%Asian
- .2%Native American

Over 83% of all students, citywide, are from low-income homes and receive free and reduced lunch (see Appendix N). Of the total number of students, the following represents those students who require special services:

- 15% bilingual
- 11 % children with special needs
- 5% of the students are eligible for gifted programs

According to the 1996 School Report Card, the citywide attendance rate is 89.6% as compared to the state average of 93.5%, with a student mobility rate of 29% compared to the state rate of 18.8%.

The nearly 600 schools reflect a variety of formats: primary schools, transitional schools, middle schools, elementary schools, upper grade centers and high schools. The system services 22% of Illinois' public school students. Of the more than 424,000 students, according to the 1997 Fact Sheet, CPS student enrollment consists of:

- 16,125 preschool
- 35,289 kindergarten
- 253,026 elementary
- 95,691 secondary
- 20,056 special education (preK-12)
- 1,798 alternative schools
- 2,469 tuitioned out

CPS employs over 45,000 people to serve its students -- 42,404 in schools, 1,534 in citywide services, and 1,180 at the Central Service Center. There are 20.5 pupils per teacher in elementary schools and 21 pupils per teacher in high schools. The 27,190 teachers employed by CPS have a racial breakdown of:

- 43.0% African-American
- 45.0% Caucasian
- 8.7% Hispanic
- 1.8% Asian
- .3% Native American

Racial breakdown of principals in the 557 schools include:

- 51.3% African American
- 37.1%White1
- 1.2% Hispanic
- .2% Asian

- .2% Native American

Each school has control of local policy and discretionary funds through a Local School Council (LSC). The LSC consists of:

- 6 parent representatives
- 2 community representatives
- 2 teachers
- 1 principal
- 1 student representative in each high school

One of the problems faced by CPS in implementing technology has been the age and condition of many of its school buildings. There are approximately 765 buildings, with additions and annexes. Only 14% of these are less than 25 years old and have adequate or near adequate electrical capacities for technology. Another 26% are between 25 and 50 years old and can be upgraded fairly easily. The largest number of schools, over 40%, are between 50 and 100 years old. The worst problems are with the 9% of the buildings that are over 100 years old. An additional 11 % were built in the late 60's, but were designed as temporary buildings intended to be used for only 15-20 years maximum. Additionally, many schools have limited discretionary dollars and are not able to fund the high cost of technology, without assistance.

As a result of the Illinois School Reform Law of 1988, as applied to Chicago, the Chicago Board of Education is now a "reform" Board with a decentralized school system where individual schools have autonomy to make their own decisions. In 1997, there was a change in philosophy that provided for CPS business and administrative functions to support the educational units and schools within the system. This is a major change from past practices and represented a unique feature of CPS reform versus that of many other large urban school districts.

The total operating budget for the CPS Central Services Center in FY97 is currently $2.9 billion for centrally managed services. Approximately 4% of this budget ($132,300,991), is appropriated for technology: Learning Technologies' share is $3,428,956; the ISBE Hub is $622,035; Department of Libraries is $517,100; and Telecommunications is $12,250,000. Management Information Systems is $116,000,000. Nearly $64 million is allocated to establish the Wide Area Network (WAN). The Learning Technologies Department of CPS has received bids to develop and install a WAN that will tie all Chicago Public Schools and related support organizations to one centrally managed and maintained facility.

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[Cherry Creek Schools] PREV UP NEXT [Drew School District]

Drew School District

Mississippi

Drew School District
HOMEPAGE

Technology Goals:

- To provide access to multimedia computers to all students and teachers for instruction.
- To improve teaching and learning through technology and the ability to increase student achievement.
- To improve curriculum delivery to help meet the needs for educational equity across the state.
- To improve delivery of professional development so that teachers and library media personnel will have the training they need to help students learn to use technology and the Internet.
- To improve the efficiency and productivity of administrators.

Implementation:

- Local area networks have been installed at each site using Netdays
- Internet access is available in each library/media center and the parent center
- Every classroom in grades K - 8 has multimedia computers that are networked with Internet access
- Every classroom in grades 9 - 12 will have multimedia computers that are networked with Internet access by august of 1999
- The District is attached to the State's Wide Area Network
- Students at Hunter Middle School use technology to publish a school district and community newspaper
- A computerized information hotline has been implemented.
- The District has constructed a webpage
- Every school has access to scanners, digital cameras, and desktop publishing software
- The District has applied for the erate to reduce costs for telecommunications and connections to the Internet
- Professional Development in technology is on-going
- The District is implementing Tech Prep
- Two teachers will be trained during the summer as Certified Novell Administrators
- A variety of multimedia software is available in each media center.
- The District has purchased accumulator software for electronically transferring student data over

the Wide Area Network

- The District has purchased Student-Level Database software
- Teachers are using Hyperstudio and PowerPoint presentations to enhance instruction
- Every teacher and student has access to the EBSCO library database.
- Internet ready laptop computers are available for loan to parents. Internet access is provided through the District's dialup access
- An Americorps volunteer was used to help teachers and students with technology

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[Chicago Public Schools] PREV UP NEXT [East Detroit Public Schools]

East Detroit Public Schools

Michigan

East Detroit Public Schools
HOMEPAGE

The community of East Detroit Public Schools has been extremely supportive of the integration of technology into the teaching and learning processes. The school district serves 6,800 students in grades K-12. There are eight elementary schools, two middle schools, one high school, one alternative high school center as well as preschool and adult education programs. The success of their educational technology program is due to the following factors and initiatives:

Planning:

- Developed a 70 person Technology Task Force with representation of every faction of the community.
- Developed a Strategic Long-Range Plan and Integrated Curriculum that was based on the Technology Task Force identified beliefs about technology.
- Hired a technology designer to build a state-of-the-art infrastructure for data, video and voice.
- Analyzed the curriculum in terms of student outcomes and identified curricular and application software that could be integrated into units and lessons to improve student learning.

Building the Infrastructure

- Purchased and mounted large monitors in each classroom. They are connected to the video infrastructure to display video signal from the classroom computer, media retrieval system (banks of VCR's, laserdisc players, and CDI's), cable television, sat elite transmissions, educational television, distance learning programs, and school broadcasts.
- Purchased and installed telephones with access to voice mail in every instructional and office location in the district. Teachers are able to call for help in case of emergency, make calls to parents about students progress, call for assistance with the classroom technology, and connect to voice mail to leave curricular updated and class information for parents to access 24-hours a day.
- Installed a data network that provides Internet access, access to reference and circulation information (from school, public and university libraries) as well as data exchange to and from every classroom in the district.
- hased and installed a new multimedia computer system and color inkjet printer for every instructional room in the district.
- Purchased and installed new multimedia computer systems, laser and color inkjet printers for every computer lab in the district.

- Purchased over $530,000 worth of software that is highly correlated to student outcomes.

Educational Technology Leadership Initiatives:

- Hired a Director of Educational Technology to provide leadership for both the instructional and management technology programs.
- Hired 8 full-time media center teachers for the elementary schools to teach information technology to students 60% of the time and 40% of the time they consult with classroom teachers to assist them in effectively integrating technology into their lessons/units.
- >Hired 4 full-time computer resource teachers for all secondary schools whose primary role is to work with classroom teachers to effectively integrate technology into the curriculum.
- Hired a full-time technical resource facilitator to manage the video and data networks, manage the elementary media retrieval system, facilitate the use of the district student record-keeping system, coordinate the repair of district computer-related equipment.
- Hired a full-time assessment/evaluation administrator to begin to develop effective strategies to evaluate whether the integration of technology into the curriculum is improving student learning.

Staff Development

Since 1991, the district has offered many staff development opportunities for staff members. From the spring of 1997 until the present time, staff development schedules have been sent out quarterly that offer opportunities nearly every day-- Monday through Thursday, as well as some Saturdays.

Grants Received

Since 1996 the district has received one Goals 2000 and three Technology Challenge Literacy Grants for software acquisition and staff development that total more than $880,000. Technology Volunteer Program

In 1991, the district began a volunteer program called C.A.S.T. which stands for Computer Aids for Students and Teachers. The program began with 5 volunteers and has expanded to over 150 active volunteers. CAST Volunteers help in every aspect of the educational technology program. The district recently won an award for this program from the Michigan Association of School Boards (MASB).
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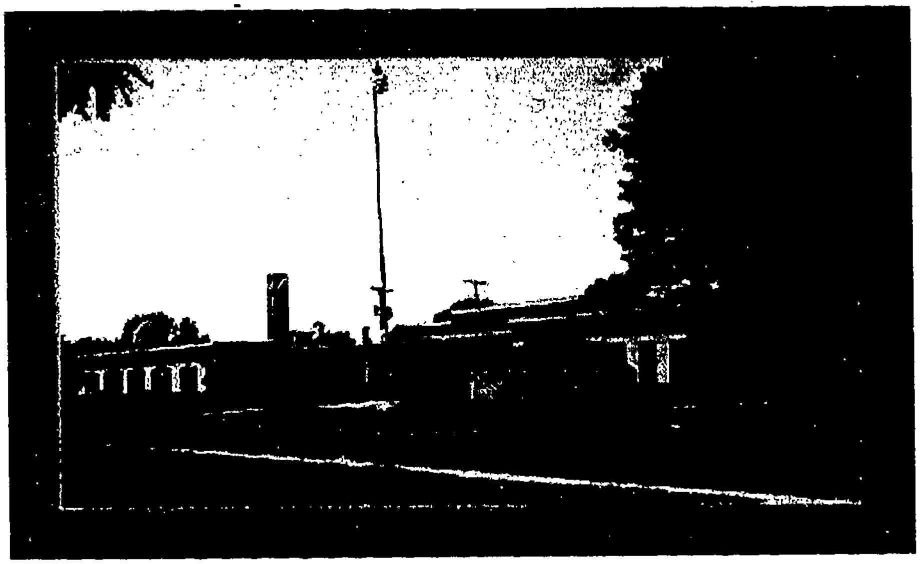
[Drew School District] PREV UP NEXT [Edgewood Elementary School]

East Detroit Public Schools



East Detroit Public Schools

Administration Building

15115 Deerfield

Eastpointe, Mi 48021

- District Information:
  Employment; Board of Education; Alumni; Street Map; District Calendar; EDS Credit Union
- Phone Directory:
  Building and Administration telephone and FAX numbers.
- Elementary Schools:
  Links to the elementary school buildings.
- Secondary Schools:
  Links to the middle and high school buildings.
- Adult & Community Education:
  Links to the Community Schools Program and the Kellwood School.
- Special Services:
  Information about Special Education in the district.
- Register of Friends:
  Reestablish contacts with old friends and classmates.
- News & Features:
  Events, accomplishments, organizations and news about the district; KISSED - Child Safety Program

Department of Educational Technology:
Technology Literacy Challenge Fund Grant; Ed. Tech. Program; Long-Range Plan; Integrated Lesson Plans;

Special Reports:
Special EDPS Report to the Community

Community Resources:

City of Eastpointe	Eastpointe Memorial Library
City of Warren	Warren Public Library
Macomb ISD	Macomb County Schools Financial and Enrollment Information

East Detroit Public Schools

15115 Deerfield

Eastpointe MI 48021

Tel. (810) 445-4400

Comments to:
(webmaster@eds.misd.net)

MADE ON A Mac

Edgewood Elementary School

Muscogee County School District
Columbus, GA

Edgewood Elementary School
HOMEPAGE

Six years ago, the leadership and faculty at Edgewood Elementary School made a commitment to provide our students with the technology that we considered imperative for success in the twenty-first century. Our progress in this endeavor has not come easy, nor has it been painless. Since our school district provides no technology budget, the funding of our goal has been, and remains, a major concern. Primarily, our technology has been purchased through the wise utilization of Georgia State Lottery funds and an initiative by the Georgia Department of Education called Pay for Performance. We feel that we have made prudent purchases of hardware, software, and provided our staff with sufficient training to feel comfortable with the technology.

As we began to focus on providing our students and staff with state of the art technology at Edgewood, our hardware consisted of five Apple 2E's on roll around carts. These computers were shared by 21 regular classrooms and various special programs. The students and teachers used these computers mainly for drill and practice and games.

When the Georgia lottery was established, the funding for technology became a very real possibility. Within 2 years, we were able to purchase one Macintosh computer for each classroom, automate our media center, and purchase the Accelerated Reader Program. Lottery funding has also provided a satellite dish, two fax machines, and four Internet connections.

Edgewood is one of two schools in the state of Georgia to be awarded Pay for Performance money each year since the Georgia Department of Education incentive program was initiated five years ago. Targeting technology as our main objective, the professional staff at Edgewood has voted each year to put our money back into the school, rather than take the rewards home. Thus, our faculty has contributed more than $100,00.00 toward technology in the building. Through this money, over the past five years, we have provided to each classroom; two Macintosh computers, one printer, one scan converter, and a 27" color monitor. We have established The Edgewood Technology Center, consisting of 24 IMac computers, one Internet connected teacher station, and one data projector. We have supplied our staff and students with four Powerbook laptop computers, three digital cameras, and two scanners. Broadcast equipment, enabling students to create and edit videotaped productions was also purchased with Pay for Performance funds.

At the onset of our technology initiative, training was driven only by individual teacher motivation. A few computer courses were offered through staff development, however, there was no specific focus. Four years ago, the Muscogee County School District hired five technology specialists an established a designated site for technology instruction. The following year, our technology specialist offered to provide our faculty with "site based" staff development courses because we felt that we were ready to focus on Edgewood's specific goals. This preliminary training proved invaluable because, in January of 1998, the State Department of Education implemented the InTech (Integrating Technology into the Curriculum) program, and Edgewood had a team of five teachers who felt ready to undergo the intensive, 50-hour training.

The five members of the original InTech team, in turn, trained the remainder of the faculty using the "Peer Teaching" concept. The instruction focused on using technology to supplement and enhance the curriculum already in place, rather that learning a particular piece of software. Our entire faculty completed the training in January 1999. Since the completion of InTech training, we feel that we are ready to begin to fully implement the technology we have purchased for our building.

Evidence of the use of technology is apparent throughout the school; in the required technology projects for grades one through six, in the required Invention Convention projects for third grade, required Media Festival ,projects for fourth grade, required Science Fair projects for fifth grade, and required Social Studies projects for sixth grade.

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[East Detroit Public Schools] PREV UP NEXT [Evergreen School District]

Edgewood Elementary

Columbus, Georgia

Home of the Eagles

Mission Statement

The mission of Edgewood School is to boldly prepare students for the future by providing an atmosphere of excellence in which children and adults are nurtured as individuals and challenged as risk-takers in the learning process.

Background

Edgewood is located in Muscogee County, Georgia approximately 100 miles SW of Atlanta on the eastern bank of the Chattahoochee River. The school serves 480 students in grades K - 6. There are 20 regular classrooms, a self-contained learning disability class, a gifted and talented resource teacher, an SIA teacher and a Reading Recovery teacher. In addition to a full-time principal, media specialist and school guidance counselor, we have a part-time assistant principal and part-time music, art, PE, orchestra, band, and remedial education teachers. Edgewood also serves as the Mini-Magnet for the visually impaired for our school district and staffs one full-time V.I. teacher and two paraprofessionals.

Technology

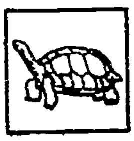
Edgewood is a Macintosh school. The Technology Team, which is a component of our site based management, addresses the technology issues that face our school. There are three Macintosh computers, one of which is connected to a wall mounted monitor for large group display, and an Imagewriter printer in each classroom. In addition, the majority of classrooms also have an ink jet printer. The computers range from LC575s to iMacs. While the Media Center is automated with 3 look-up stations, there is no school-wide network. A variety of equipment is available including flatbed scanners, digital cameras, video cameras and video editing equipment. Four PowerBook 5300s are available for teacher use.

A student production lab has been established within the last year. We have 24 iMac computers, scanners, ink jet printers, and a teacher station connected to a projection device for large group display. Classes are scheduled on a regular basis with additional time slots available on an as needed basis.

Each classroom's wall mounted monitor (including a VCR) is connected to the distribution system and in conjunction with our satellite dish, allows for video use throughout the building. Additional video equipment is available including three camcorders and editing equipment to enhance video capabilities. A Broadcast Club has been organized as an extracurricular activity to provide opportunities for students to become proficient in the use of video and editing equipment.

Internet access is through Mindspring, Inc., an Atlanta internet service provider and is available in the Media Center and computer lab.

Cool Projects At Edgewood

 Literature Day  River Kids  Construction

We would like to hear from teachers and students.

Email us now!

Evergreen School District

Washington

Evergreen School District
HOMEPAGE

BACKGROUND

Evergreen is a suburban school district with approximately 21,000 students housed in twenty-seven schools. A rapidly growing district, Evergreen will open its third high school in the fall of 1999, and a middle school and an elementary school are under construction.

EVERGREEN'S TECHNOLOGY IN THE 1980s

The district has long supported an innovative, technology-infused vocational/technical program and in 1983 had the first high school level word processing lab west of the Mississippi. Student and fiscal management systems are linked to the State of Washington system, WSIPC (Washington State Information Processing Cooperative). In the late 1980s Evergreen School District begin installing e-mail and voice mail systems and creating local area networks to support these services. In 1989 a district junior high school was awarded a $500,000 21st Century School grant, marking the first time that technology was deployed to every classroom within a school.

TECHNOLOGY PROGRESS IN THE 1990s

With the formation of the District Technology Committee in 1990, Evergreen SD began a thorough assessment of the role of technology to increase student learning and staff productivity. Following the lead of this committee, Evergreen began its steady progress in the 1990s to deploy technology to every classroom and office in the district.

FUNDING

A Capital Needs Bond approved by the voters in 1992 allocated $7,865,000 for technology, allowing the district to provide a base level of technology and connectivity to every school. A second bond approved in 1994 provided an additional $14,704,250 for technology. In February 1999 a capital technology levy for $6,840,000 won 57% support of the voters but failed because it was short of the 60% super majority required by the State of Washington.

SCHOOL LEVEL PLANNING FOR TECHNOLOGY

To access the technology funds approved by the electorate, each school developed a comprehensive, long term school improvement and technology plan. School technology plans included educational goals, needs assessments, staff development, software selection, and evaluation of educational effectiveness.

DISTRICT LEVEL PLANNING FOR TECHNOLOGY

To meet our sustainable vision of technology used to support effective teaching and business practices, Evergreen School District approaches technology from a return on investment (ROI) viewpoint. When considering the deployment of technology for a particular program or task, managers calculate the total cost of the implementation. For instance; what is the actual cost when considering equipment and software purchase, educational benefits, required facility modifications, staff training, technical support, ongoing maintenance, and eventual replacement. When it can be determined with confidence that the proposed technology can perform the tasks better, or faster, or cheaper, or to higher levels than with the traditional methods it replaces, then Evergreen will proceed with its implementation.

EVERGREEN SCHOOL DISTRICT TODAY

Approximately 4,500 computers are used in the district and all are networked and have Internet access. Each classroom has a high speed Internet access at three or more locations and a phone with district voice mail and direct dial functions. A systematic plan was followed to provide adaptive equipment so all students, including those with handicapping conditions, have equitable access to current technology. A computer services department provides helpdesk assistance and technical support in-house. Technology staff development and curriculum integration is a focus of Evergreen School District and is provided by an instructional technology department.

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[Edgewood Elementary School] PREV UP NEXT [Fabens School District]

Fabens School District

Texas

Fabens School District
HOMEPAGE

eeZone TEXAS is an online community in which teachers collaborate with research organizations and the private sector to design and evaluate new best practices for using technology effectively in the classroom. Our participants, currently numbering nearly 50,000, represent 22 school districts, five regional education service centers, three universities, four research centers, and one private sector partner. Our mission is to serve as a cooperative of researchers, practitioners, and students, who together will help define, publish, and promote replicable strategies for improving education with effective technology practices in the nation's classrooms.

eeZone TEXAS uses a Web-based software application to deliver interactive content and technologies that help students develop critical thinking and analysis skills. Our cooperative uses the Internet to coordinate activities among participants, who are widely distributed across the state. The application runs on a central server, and participants access the content and interactive tools using networked computers. The server-side application manages user authentication, access, and data tracking, and the client applications run in a Web browser. The Texas Education Agency is evaluating this distributed client-server model for delivering electronic instructional materials as a more flexible and cost-effective alternative to traditional textbook publication and distribution.

Students collaborate in teams within their school and across the state as they work through interactive, inquiry-based projects, which are accessed online. The projects use environmental education as an integrating curricular context, as it naturally lends itself to interdisciplinary team teaching that supports the core subject areas. Existing and forthcoming projects include A Virtual Tour of the Edwards Aquifer; a Virtual Wildflower Collection; Using GIS Technology to Explore Earth Systems; A Sustainable System for Industrial Water Re-use; Designing Air Quality Improvement Strategies for Texas; An Investigation of Campus Littering Behavior; A Simulated Landfill Siting; and Perspectives on Graffiti.

Teachers join interdisciplinary teaching teams as part of the program's professional development activities. Curriculum and instruction specialists, assessment specialists, and teachers form working groups to propose new interactive project ideas and revise existing materials. The eeZone TEXAS Web site provides group support software to facilitate these online collaborations. As they work through the curriculum design process, teachers develop new skills, inform their teaching practices with new education research, and emerge as strong school leaders.

Scientists and researchers at the state's universities and agencies contribute expertise and the products of their research work, whether that be in the field of environmental science or in education. eeZone TEXAS provides a forum for these experts to share their extensive research and development, which has been funded through previous public expenditures. Working with the curriculum design teams, these experts assist in creating new inquiry-based educational projects. Modifying research products to be used in 6-12 grade classrooms can offer useful feedback from the field; it also encourages researchers to consider outreach and dissemination possibilities when designing their research projects.

Evaluators gather much of their data through online instruments that examine how the technologies are being integrated into the school curriculum. These online instruments provide rapid feedback so participants may refine their teaching strategies throughout the year.

In the coming year we intend to expand the eeZone program to additional states, expanding access to our interactive content and online professional development resources.

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[Evergreen School District] PREV UP NEXT [Gold Oak Union School District]

Gold Oak Union School District

California

The Gold Oak School District is comprised of two school. Gold Oak serves students in grads K-5 and Pleasant Valley the 6-8 population. At present, Pleasant Valley School has a PC computer lab with 29 Pentium computers to the Internet and a Mac Lab with 16, 5200 Power Mac's also connected to the Internet. Teachers at Pleasant Valley have access to both labs on a regular basis. All teachers at Pleasant Valley have at least one network capable computer in their classroom except for the P.E. and music teachers. At Gold Oak the computer lab has 28 computer stations (a combination of Pentium PCs and Mac LC 580's) with Internet connection, which also can be accessed on a regular basis by all teachers. More than 60% of the teachers at Gold Oak School have at least one network capable computer in their room.

Goals

- Use technology as a tool for teaching and learning
- Research the effectiveness of technology as it relates to standards and curriculum
- Empower students through the creation of a student level technology support system
- Empower parents by using technology to increase literacy skills and give access to student information and Internet resources
- Make technology available in all areas of the school community

WHAT HAVE WE LEARNED?

- The classroom environment must be "technology-rich" in order for change to occur.
- Innovation is driven by the sharing of great ideas.
- Dialogue, whether on-line or face-to-face, becomes an avenue for discussing both successes and frustrations.
- Training tied to standards and to classroom instruction is makes learning meaningful.
- Technical support is essential to student/teacher use of technology.
- Technology in the classroom facilitates constructivist practices.

THE INSTRUCTIONAL TECHNOLOGY EXPERT PROGRAM (ITE)

- Ninety teachers from across the district are trained in the ITE program.
- Thirty participants form each of three consecutive cohorts who receive 9 full days of training as well as after-school workshops throughout the year.
- Full day training for ITE teachers focuses on technology integration with curriculum and district

standards in the area of language arts. Workshops focus on the use of specific technology tools.

- ITE classrooms are equipped with a minimum of six networked multimedia computers, color inkjet printer, laser printer, digital camera and flatbed scanner.

THE TECHNOLOGY ASSISTANCE PROGRAM (TAP)

- The TAP program trains thirty students per year at the 4th and 6th grade levels.
- These students are selected by ITE teachers from each cohort and serve as a student level technical support system.
- Trained on a bi-weekly basis, they take classes before or after school which focus on classroom software as well as basic computer and network troubleshooting. In the near future, these students will have the opportunity to become Apple Certified technicians.

THE PARENT PROGRAM

- The parent program offers classes to parents on an eight-week course of study.
- Classes are in Spanish and English, and held after school hours and on Saturdays.
- Topics in the parent program range from computer basics and classroom software, to e-mail, the Internet, and multimedia.
- The purpose of the parent program is not simply to offer classes in skill development but to encourage parents to serve as a support mechanism for technology-rich classrooms across the district.

THE PROFESSIONAL DEVELOPMENT CENTER (PDC)

- The PDC is a state-of-the-art facility for staff development in technology. All ITE training, the TAP program and parent classes are held in this center.
- The PDC is comprised of thirty networked, multimedia computer workstations, scanners, digital cameras, video cameras, and laser printers.
- The design of the center fosters collaborative learning, as each group of four workstations are interconnected. All workstations are ergonomically designed such that monitors reside below the level of the desk. This allows for easy communication between group members.

LAPTOP LOAN PROGRAM

To encourage learning at all moments, laptops are made available to teachers, parents and students involved in the programs mentioned above. Teachers use the computers for instruction and network management in the classroom, and to access the network from home. Students and parents use the computers to reinforce what is learned in class and to communicate with teachers via e-mail.

COMMUNITY CONNECTIONS

In the coming year, community centers across Lennox will be provided with a computer kiosk for access to the Lennox Network and the Internet. The first to receive such access is the Healthy Start Community Center. Future locations include the Lennox Public Library, the Lennox Sheriff's Station, and the Richstone Family Center.

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[Fabens School District] PREV UP NEXT [Helena School District]

Helena School District

Montana

Helena, Montana, nestled at the base of the Rocky Mountains, is Montana's capital city. The Helena School District, which serves 8188 students, includes two high schools, two middle schools, ten elementary schools, an alternative high school, a transitional middle school and an Instructional Materials/Technology Training Center. The district employs an exceptionally well-educated staff of 500. These highly motivated professionals serve our children, schools and community with incredible dedication and compassion. Helena Public Schools has a long tradition of excellence in all areas whether it be academics, the arts, technology, or sports. We continue to strive to meet the mission of the Helena Public Schools, which is: to challenge our students to maximize individual potential and to become a competent, productive, responsible, caring citizen.

District Technology Plan for the School District was begun in 1990 and has been completed. It is a dynamic document that is constantly revisited and revised. Each school includes a technology section in their Annual School Improvement Plan. Each building's Annual School Improvement plan must address the role of technology in enhancing teaching and learning. Further, the plan must describe how technology will be acquired and used to maximize improved student learning.

The District established a District Technology Coordinator position in January of 1997. This position oversees and coordinates the implementation of technology in the District. A network manager position was created and filled during the 1998-99 school year. This position is responsible for security at all levels and for all systems. Network authentication protocols are being established and implemented. Business applications, student management applications and library applications are password protected. An Elementary Technology Specialist position was established in 1994 and in 1997 responsibilities of the Training Center Coordinator were included in that position. Library Media Specialists in some locations have accepted responsibility for building level technology support. Each high school has a technology teacher position and the two middle schools have also established technology teacher positions.

The District Technology Training Center was established in the fall of 1996. An extensive Professional Development program was developed and professional development opportunities for District teachers as well as teachers from surrounding Districts and community members continues today. The Center operates in the evenings, on weekends and throughout the summer months. Non district staff are charged a nominal fee to help defray overhead costs.

The District has invested in and implemented local area networks in its high schools, middle schools and the first five elementary schools. The remaining elementary schools are scheduled to be wired during the 99-00 school year. Sites with a local area network are connected in a wide area network using wireless communications tools. The District selected and implemented a District wide K-12 Student Management System during the winter of 1997-98.

High school and middle school libraries are automated and provide a wide array of resources both electronic and print which support teaching and learning. Elementary libraries will be fully automated in the fall of 1999.

All students and staff in our high schools have comprehensive access to the tools of technology. Access includes classroom, mini-lab, full lab and library lab access. Further all high school instructional sites have both local and wide area network access. The two middle schools and ten elementary schools have centralized access to network resources and varying levels of access to technology tools.

Each school has a District web site which highlights school activities and student work. Each high school web site also includes instructional information provided by classroom teachers. Email accounts are provided for all staff members.

A set of essential technology skills has been identified at each grade level. Work continues to insure that technology is used as a tool to support teaching and learning and that fundamental skills be used in the context of the curriculum. Efforts at evaluation have tended to be tied to specific programs. The Accelerated Reader Program has been extensively evaluated over a period of five years. Student achievement has been documented through a series of standardized tests, student performance records and other assessments. Students participating in the Problem Based Learning project have provided anecdotal evidence of improved achievement through oral assessments. Additionally, students participated in pre and post assessments which measured their technical abilities. No evaluation has established an absolute and direct link between student achievement and technology integration.

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[Gold Oak Union School District] PREV UP NEXT [Henrico County Public Schools]

Henrico County Public Schools

Virginia

Henrico County Public Schools
HOMEPAGE

Technology

The Department of Technology is responsible for the technical implementation, maintenance and support of instructional technology initiatives, ongoing technology programs and for technology production services in the school division, kindergarten through grade 12.

Department of Technology functions include:

- Instructional and administrative computing network design, installation, repair and support

HIGHLIGHTS:

Henrico County Public Schools has historically been and continues to be a state and national leader in the application of technology to K-12 instructional applications. Henrico began televising high school distance learning courses in 1984 and has implemented computer Integrated Learning Systems (ILS), videodisc applications for Science and Mathematics, a student/teacher electronic mail system and is currently working on the implementation of a county-wide Metropolitan Area data communications Network (MAN) utilizing an Instructional Cable Television Network or I-NET. This system will provide data communications between all schools and direct internet access to all computers on school networks while avoiding typical high costs for telecommunications charges.

Major Technology Initiatives already in Place in Henrico Schools

- Elementary Classroom Computer Initiative
- Institutional Cable Television Network (I-NET) and television distribution systems in each school
- Two-way video and audio instruction between school sites for specialty/low enrollment courses
- Satellite reception capability in each school
- Library Automation Initiative Implementation (all schools)
- Secondary Technology Initiative

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[Helena School District] PREV UP NEXT [Hope Valley Elementary School]

Hope Valley Elementary School

Chariho County Schools
Rhode Island

Chariho County Schools
HOMEPAGE

1. Implementation of Technology

We are a K-4 elementary public school. Hope Valley is one of four elementary schools in the Chariho Regional School District. Please see Hope Valley Elementary School Web Page for profile, belief statements, and objectives. We implement technology in every grade level, in every subject area. Our work reflects broad-based use of technology from electronic information gathering emphasizing information literacy skills, all the way through to the formal product/project presentation. Through inquiry based research, students are developing more advanced questioning techniques and asking essential questions that lead to every more research and inquiry and a deeper understanding of the subject matter.

The Chariho District Web Site provides access to curriculum resources, school web pages, classroom pages, and student work. It has evolved over the past three years of its existence and reflects the district's increasing implementation of technology. Quality of student work using technology is evident through their contributions toward developing award-winning websites:

- Sands of the World: awarded TechCorps, WNET, and recognized in Classroom Connect Magazine, March, 1999
- "Internet Sites for Kids"is indexed by several other school web pages in the state as a summary resource site for child-oriented search engines. Twelve outside websites throughout the country index Hope Valley School's web site. EduChoice Award for providing outstanding educational material on the web. Tech Corps (a cooperative association of commercial and educational interests) will showcase this site at its Web Nite 2.0 in June.

2. Wide Area Networking and Local Area Networking:

Rhode Island's RINET provides connectivity to all teaching professionals in the state, with the cost of service assessed to the various school districts. Through RINET, teachers have internet and email services. Locally, the Chariho Regional School district operates its own server, and affords connectivity to all schools in the district. Every professional and para-professional has an email account. Buildings are networked, and every elementary classroom has a pentium computer connected to the network. Teachers who participated in the RITTI program have laptop computers, which also can access this network.

3. Preliminary Evaluative Work of Hope Valley Elementary School:

- Information Works School and District Achievement and Performance Reports data based on standardized testing indicates that students at Hope Valley performed better than expected given demographic indicators.
- 1998 SALT Report for Hope Valley Elementary School.
- **1999 SALT Visit Report**(not yet published) cited exemplary integration of technology into the curriculum at Hope Valley School. In this SALT report, the Hope Valley web site was described as an exemplary source of information for parents, teachers, and community
- **Teacher observation** has found that technology has motivated and excited students, even those who previously disliked school work or were indifferent. Students have been forced to employ higher order thinking skills in evaluating and utilizing the information they encounter.

4. Timeline for Technology Implementation:

- District Technology Plan 1993
- District Technology Initiative Phase I, June 30, 1996
- District Technology Initiative Phase II, June 30, 1997
- Champlin Grant June 1998
- District Technology Initiative Phase III, June 30, 1998
- District Technology Curriculum 1999 is in the final stages of approval. It reflects current practice as well as prescribes additional and continual technology integration. Will serve as basis for evaluation of programs beginning September 1999.

5. Professional Development:

Staff needs assessment area of technology training has been done annually for the past three years. Workshops conducted by district staff, mostly RITTI trained, and financed through RITTI grants and district funds, have addressed every topic in which teachers felt they needed training. Impetus for wanting more training comes from seeds planted by RITTI, and it drives that training to a point where teachers increasingly progress as they realize the potential impact of technology in education.

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[Henrico County Public Schools] PREV UP NEXT [Hundred High School]

Hundred High School

West Virginia

Hundred High School is located in a small rural community in West Virginia with an enrollment of approximately 170 students enrolled in grades 9-12.

During the 1998-99 term, the school began with the implementation of the NetSchools solution. With this program, every student in the school was provided a durable StudyPro™ laptop, which could be used both as a stand-alone computer and as a wireless, networked computer. The laptops were loaded with a number of applications including MicroSoft Works word processing, spreadsheet and database software as well as a popular browser, email, a presentation creation package and a graphing program.

Not only does every student have a laptop, but also every teacher was given a laptop for instructional as well as classroom management tasks. In addition to the same application packages, teachers were provided with an email package, an Internet browser, and special classroom management tools. These tools include AIS Desktop Monitor which allows each teacher to control student laptops from their desks, and the Curriculum Browser/Search Tool developed by NetSchools for access to a large database of tested Internet sites that have been correlated to the West Virginia Instructional Goals and Objectives.

The teachers have incorporated this technology into daily classroom instruction in a number of ways. Through the use of several application software packages students are able to complete assignments using the application tools, using email for receiving and submitting assignments or collaborating with other students on group tasks, accessing information using the Internet browser, creating presentations to share with others and participating in mentoring projects.

Through the Wetzel County Board of Education, an important vehicle for enhancing school home communications has been added. Students and teachers have local dial-up access to the school server which provides the opportunity for accessing files stored on the server as well as the Internet from home during the evenings and weekends. Parents/guardians were included in the initial training and dissemination of the technology, and were encouraged to communicate with teachers and students using the technology provided to their children. Parents also have the opportunity to observe what their children are doing in the classroom by viewing assignments and files on the laptops.

To increase the level of success for this program, the package purchased from NetSchools provides on-site teacher and student instructional training, and technical support throughout the first year of implementation. Evaluation data of the program is being collected on a continual basis to establish the effectiveness of the program in terms of student learning as well as teacher progress in delivering instruction through this new technology model.

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[Hope Valley Elementary School] PREV UP NEXT [Jennings School District]

Jennings School District

Missouri

Jennings School District
HOMEPAGE

Beginning in the summer of 1997, the Fairview Elementary School of the Jennings School District was selected to participate in a Missouri pilot project known as MINTs, Multimedia Interactive Networked Technologies. MINTs trained the teachers, delivers high-speed Internet connectivity into the classroom, and places technologies on the teachers' and students' desks. The purposes of the MINTs project were to eliminate the technology barriers, change (reform) teaching styles and strategies, and significantly improve student performance in historically high "at risk" and low achieving urban school districts.

Missouri funded two classrooms in each of six high "at risk" urban school districts. Two classrooms--a fourth grade and a fifth grade--in Fairview participated in the technology project. Each class was provided with a student to computer ratio of two to one, a teacher workstation consisting of a computer, electronic white board (smart board) and projector, two printers (one color and one black and white), a scanner, and a video camera. In addition, each classroom was connected to the Internet with a 1 0-Mbps line.

One classroom focused on student improvement in science and the other classroom focused on the improvement of reading and writing skills. However, as will be evidenced in Section 3, there was significant improvement in student performance in other areas as well as significant reform in teaching styles and strategies.

In addition to the technology available in each classroom, new student desks (workstations) were designed and purchased. The student desks were ergonomically designed and also provided workspace for a student on each side of the monitor. The newly designed student desks are visible in the video accompanying Section 4.

The project is now being expanded to 14 additional (16 total) classrooms throughout the district. Fourteen teachers have volunteered for the ongoing teacher training program necessary to replicate the hi-technology classrooms. Each of the 14 classrooms will be equipped essentially the same as the pilot classrooms with the exception of the connectivity. The new classrooms will have a T-l connection to the Internet.

At the same time, the district was piloting the technology in the classrooms and expanding the hi-tech classrooms throughout the district, the district was also expanding its technology support staff. Therefore, for the 1999-2000 school year, the district will have 16 hi-tech classrooms grades 4-12; two technology instructional specialists will be available full-time to insure efficient integration of technology into the curriculum; and three technology support staff will be available to insure efficient operation of the classroom technology.

NOTE: The district has two to three modern computer labs in each building. The labs are not considered innovative and are, therefore, not part of this profile.
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[Hundred High School] PREV UP NEXT [Kayenta Unified School District]

Kayenta Unified School District

Arizona

Kayenta is a small rural Navajo community located in an isolated region in the northeastern corner of Arizona, near the magnificent Monument Valley. This school district serves 2600 students from Kayenta and several other smaller, more rural communities. The nearest public library is 100 miles away, while the nearest museums, bookstores, and universities are 150 miles. This isolation has provided the motivation to use technology to assist in increasing literacy, while permitting students to sustain critical elements of the rich traditional life of generations of Dine.

The Kayenta Unified School District (KUSD) committed itself to the implementation of educational technology about ten years ago under the leadership of former superintendent Bob Roundtree. At that time, a long-range technology plan was outlined that specified infrastructure development. This aggressive technology plan began with district administrators, expanded to office staffs, and eventually extended to every classroom. Thus the long-range plans for infrastructure were put into place, along with technology support systems.

Presently, all six school and administrative buildings, and all classrooms, offices, and administrators are connected to an Internet/intranet email system. There are currently 550+ desktop workstations; both Macintosh and Windows based. Infrastructure upgrades will continue within buildings and classrooms during the coming school year.

Kayenta's Staff Development Office began training teachers in the personal use of computers, Internet, and Intranet email three years ago. During the 1998-99 school year teacher's skills were assessed using a locally developed assessment instrument based on a five-stage model of Classroom Technology Use. Initial results show that almost all teachers are comfortable with some use of computers, but that few have fully integrated technology into classroom instruction. Each teacher's classroom technology use is now focused through an Individual Technology Action Plan that will be completed and renewed annually.

An initial internal evaluation indicated that in order to maximize student learning the efforts made towards training teachers would need to be expanded to include students, support staff and eventually community members. This presents an uncommon challenge, since there are no other sources of multimedia technology available to the larger community population.

Determining ways to complement traditional instruction and values, while using technology to increase literacy and reduce isolation is the compelling challenge faced by Kayenta Unified School District and other rural isolated school districts.

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[Jennings School District] PREV UP NEXT [Kenton County Public Schools]

Kenton County Public Schools

Kentucky

Kenton County Public Schools
HOMEPAGE

With the Kentucky legislative action of 1992 awarding schools district Ed-Tech funds to be matched dollar for dollar by the local school district, Kenton County Schools began a technology implementation to support the curriculum. 12 months were spent in organizing a district technology committee and planning for the future implementation. It was decided that as funds were disseminated from the state on an annual basis, we would purchase a few computers and printers and combine the remaining 1st year funds with the 2nd year funds and cable all of the buildings. In combination with construction going on in the district, we felt that creating the infrastructure was the key to a long-range success. All future funds would be assigned to the schools based on their enrollment and inclusion of technology in the building consolidated plan.

After completing the cabling to each classroom, library and administrative area, Kenton County Schools began adding school buildings to the WAN (wide area network). Professional development began by focusing on writing and using a word processor as a tool for that activity. Teachers were also trained in the instructional uses of E-mail. As teachers acquired these skills PD began to focus on instructional aspects of the Internet. As each year passed a new concept, either tool or supplemental content software, was introduced into the professional development plan.

As more equipment was installed in each school the district hired several full time technicians. While that took care of hardware failure, it did not address the day to day operator issues that occurred. The district staff implemented Technology Teams in each building to build capacity in each school. We complemented that with students who became part of the Student Technology Leadership Program. We found it necessary to have a team of teachers, staff and students that were on site and could support minor failures and one-on-one training needs. In organizing this support structure, we held annual summer training sessions for each group, correlating the training's to cover the same material.

With the addition of the TLCF (Technology Literacy Challenge Fund) offers, Kenton County Schools was able to purchase items other than computers and printers that added to the curriculum. The first year digital cameras and scanners were purchased. The professional development was focused on using that equipment to create web pages. It exceeded our expectations. The second offer of TLCF was used to train 1/6 of the teaching staff on the instructional use of a presentation tool (Hyperstudio). Each participant had to complete 3 projects including a student project from their classroom. A web page was created with links to the projects for teacher sharing. The Year 3 offer will be used to purchase projection devices for students to present multimedia presentations incorporating the items from Years 1 and 2.

While each year we continue to add more up-to-date workstations and printer to each school based on their enrollment, we have found that the TLCF offers have made a huge impact. As this is a district with low free and reduced lunch students (rated at 52%), we qualified only for communication reimbursement from the E-rate. This has reduced the annual cost of leased lines for Internet access to our schools.

With this school year we added a teacher as a district trainer to the technology staff. This person conducts a weekly 3-hour technology PD based on the various tools and curriculum software available to teachers. She is also made available to schools, as requested, to work one-on-one with teachers during their planning or school created time. We currently focus on the Teacher Standards adopted by the Kentucky Professional Standards Board and make sure each person is informed which standard each training addresses.

We are looking for measurable progress in the area of technology with our students. We participated in a survey from the Milken Family Foundation focusing on teachers, principals and the district's perception of technology and it's integration. We also survey schools annually for needs, implementation and perceptions.

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[Kayenta Unified School District] PREV UP NEXT [Kuna School District]

Kuna School District

Idaho

The Kuna School District is a rural district 20 miles southwest of Boise. Although Kuna is primarily a farm and agriculture community, many who work in high-tech industry in Boise and surrounding towns, for companies such as Hewlett-Packard, Micron Electronics, and Micron Technology, have opted to live in Kuna, and send their kids to the Kuna School District.

Kuna School District's commitment to educational technology began in 1992, when district funds were committed to begin installing local area networks in its schools. Over the next 6 years, all schools, and all classrooms in the district were wired for Internet access through the building LAN.

Integration into classroom teaching started slowly, and has exploded in the past two years. In 1994, the district started a pilot project, where 2-3 teachers per building were given a bank of 5 computers per room, and were asked to experiment with using technology in their teaching. Today, all elementary classrooms in the district have 3-6 computers, and all secondary classrooms have at least one computer, with access to more in shared labs.

The district has a structured professional development plan for technology integration, which allows teachers to choose from a wide variety of training and development opportunities, including both technology skills and classroom integration strategies. Teachers can choose from after-school technology classes, student-teacher mentorships, help from teacher integration specialists available in each building, and informal help from grade level or department technology coordinators.

The district is committed to continual needs assessment and evaluation of the technology program, including evaluating the impact of technology use on students and teachers. Starting this year, a specific plan is in place to yearly evaluate the impact of technology on student learning. At this point, evaluation efforts are rudimentary, but with more training and practice, the district expects to have valuable data to share with other districts on the benefits of technology integration.

The goal of the Kuna technology program is the same as that of the district - that all students will achieve their highest potential. We believe that educational technology, appropriately used, has the potential to motivate and challenge students to not only achieve their highest potential while in our care, but to become competent, life-long learners.

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[Kenton County Public Schools] PREV UP NEXT [Lennox School District]

Lennox School District

California

Lennox School District
HOMEPAGE

GOALS

- Use technology as a tool for teaching and learning
- Research the effectiveness of technology as it relates to standards and curriculum
- Empower students through the creation of a student level technology support system
- Empower parents by using technology to increase literacy skills and give access to student information and Internet resources
- Make technology available in all areas of the school community

WHAT HAVE WE LEARNED?

- The classroom environment must be "technology-rich" in order for change to occur.
- Innovation is driven by the sharing of great ideas.
- Dialogue, whether on-line or face-to-face, becomes an avenue for discussing both successes and frustrations.
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- Technical support is essential to student/teacher use of technology.
- Technology in the classroom facilitates constructivist practices.

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- Ninety teachers from across the district are trained in the ITE program.
- Thirty participants form each of three consecutive cohorts who receive 9 full days of training as well as after-school workshops throughout the year.
- Full day training for ITE teachers focuses on technology integration with curriculum and district standards in the area of language arts. Workshops focus on the use of specific technology tools.
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- Classes are in Spanish and English, and held after school hours and on Saturdays.
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- The PDC is a state-of-the-art facility for staff development in technology. All ITE training, the TAP program and parent classes are held in this center.
- The PDC is comprised of thirty networked, multimedia computer workstations, scanners, digital cameras, video cameras, and laser printers.
- The design of the center fosters collaborative learning, as each group of four workstations are interconnected. All workstations are ergonomically designed such that monitors reside below the level of the desk. This allows for easy communication between group members.

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[Kuna School District] PREV UP NEXT [Little Falls Community Schools]

Little Falls Community Schools

Minnesota

Little Falls Community Schools is located in Morrison county in rural Minnesota. Morrison county has an unemployment rate of 7% which is well above state and national averages. Per capita income in Morrison county is $16,563 which places Morrison county 7th lowest out of 87 Minnesota counties. Over 55% of our elementary students qualify for free and reduced lunch. Educational attainment levels are low; 31% of Morrison county adults ages 18 and older have not obtained a high school diploma, and 85% of Morrison county adults ages 18 and older have not obtained a post secondary degree. Despite financial and educational poverty, the residents of Independent School District 482 passed a ten year $10 million technology referendum 5 years ago.

Over the course of five years, the school district has established its own local area and wide area network (LAN and WAN) for data and voice connecting all buildings within the district. A network administrator was hired to establish the LAN and WAN infrastructure. Internet connections and a registered domain name for LFCS was established. After the internet connections were in place firewall, domain servers, web servers, Internet mail server, proxy server and lightweight directory access protocol (LDAP) and dial in access were also established.

District infrastructure expanded to include an internet drop in every classroom, a workstation on every teachers desk and a 1:3 computer to student ratio throughout the district. In the fall of 1997 Little Falls Community Schools began an aggressive mission of moving the 1:3 ratio to a 1:1 ratio through a laptop initiative. During the first year of implementation all 5th grade students had laptop computers (eMate 300) and in the second year all 5th through 8th grade students (approximately 1100 students) had laptop computers. During the first year teachers received monthly staff development training. Staff development for 6th through 8th grade teachers was minimal and a marked change in year two implementation was evident.

Certified teachers were hired during the initial phases of the technology referendum to specialize in staff development and integration of technology into the existing curriculum. A district technology tool kit for students and staff is in place. Technology integrationists at the elementary level have established a scope and sequence of technology skills in relationship to reading, writing, mathematics and inquiry across all curricular areas. Technology integrationist function in a variety of ways through out the district. However, the role most closely related to district vision and goals occurs when a technology integrationist assists classroom instructors in the integration of technology into their curriculum by modeling, peer coaching and supporting educational technology in their classroom.

Staff development opportunities are available throughout the year for teachers. Technology integrationist are the instructors for these classes. In addition technology integrationist are involved in various teaching and learning committees as well as graduation standards committees. After district scope and sequence is revised and aligned with graduation standards, the technology integrationist begins seeking additional resources to enhance and reinforce the curricular goals. The integrationist creates and provide sample lessons aligning with goals and then assists the classroom teacher in implementation of the lessons.

Little Falls Community Schools has a variety of special projects in place as a result of technological infrastructure, integration of technology into the curriculum, local history and community support. Please go to the following sites to gain information about the Fresco Project, Riverwatch Project, Foreign Exchange Teacher Program, Camp Ripley Job Shadowing Program and the Laptop Initiative.

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[Lennox School District] PREV UP NEXT [Mantua Elementary School]

Mantua Elementary School

Virginia

Mantua Elementary School--Mantua Center, located in Fairfax County, Virginia, is home to a diverse student population of 820 general education, deaf, English as a second language, gifted, and learning disabled students. The school encompasses three connected school programs-the Total Communications Center for the Deaf, the Gifted and Talented Center, and the base school.

Mantua A Basic School Powered by Technology integrates a technology-rich, interdisciplinary environment within the framework of the Basic School, the educational philosophy of the late Dr. Ernest Boyer.

At Mantua, technology is viewed not as an end in itself, but rather as a tool that augments the following four pillars of the Basic School:

- the School as Community (bringing into focus how people relate to one another and work cooperatively to solve problems),
- a Curriculum with Coherence (bringing an interdisciplinary approach to the acquisition of knowledge),
- a Climate for Learning (providing the physical and motivational factors necessary for effective teaching and learning), and
- a Commitment to Character (emphasizing how the school experience shapes the ethical and moral lives of children)

Students and staff use technology to make connections across disciplines and to integrate and apply literacy skills in language, mathematics, and the arts. The Basic School accommodates many learning styles and theories and involves parents and other community members in the learning process. Rather than focusing on a specific learning paradigm, our teachers select to integrate coherently the methods that are most appropriate for the objective at hand, while providing an environment that supports an effective education for every child. Technology is one tool that empowers this acquisition of knowledge; students use technology to simplify, facilitate, and enhance the learning process.

The curriculum of the Mantua Basic School includes all of the traditional fields of elementary study. The eight commonalties of the Basic School are unique lenses through which we view the traditional disciplines and create interdisciplinary connections. Teachers are seen as leaders, facilitators, and mentors, well grounded in the art of teaching and well trained in the use of the most current computing equipment and software applications. Children exposed to interdisciplinary units of study arc becoming literate, cooperative, problem solving, self-motivated learners and that is what Mantua is about. What most distinguishes education at Mantua Elementary--Mantua Center is that our students are not passive recipients of knowledge, but rather, active participants in the full educational process.

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Montgomery County Public Schools

Maryland

Montgomery Public Schools
HOMEPAGE

Since the Global Access initiative began in 1994, the Department of Educational Accountability and the Office of Global Access Technology have worked collaboratively to evaluate the implementation and effectiveness of various aspects of the program.

During the past five years, the emphasis of the evaluation has changed as new questions arose. The evaluation has had three phases.

Phase I: Focus on Implementation

- Was the Global Access project implemented as planned?
- What factors determined the extent to which the program was implemented the first year?

Phase II: Focus on Use

- What were the computer applications and telecommunications resources that teachers and students were using?
- Were teachers using technology for administrative functions, planning and presenting instructional material, and incorporating technology into classroom activities with students?
- Were teachers beginning to use multiple applications in all three areas?
- Were teachers beginning to change their teaching practices as a result of the capabilities of technology resources?

Phase III: Focus on Instructional Integration with Students

- Given that teachers are technology users, which models of staff development are most effective in promoting technology integration into the curriculum? .
- What are the conditions (school, content area/department, school system) that promote or hinder the effective use of technology to promote student learning?
- What are appropriate methods that can be used to evaluate the effect of technology resources on student learning?

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Middletown County Schools

Ohio

Middletown County Schools
HOMEPAGE

TLCF Resource Usage

- each of the six tech centers will include 4-6 computers, TVs VCRs, a scanner, a printer and other technology equipment
- several sets of portable student computers
- combine district and TLCF funds to install one computer in each classroom
- staff development

District Goals

- to establish one multimedia technology center for each of the building's six interdisciplinary academic teams (150 students to each team)
- to increase proficiency test scores
- to improve communication among students, teachers and parents
- to make student learning better

Indicators of increased learning

- evaluation criteria for student work with technology developed by district personnel in conjunction with the Ohio SchoolNet Lesson Labs
- improved proficiency test scores
- extended student electronic portfolios that are assessed by teacher-developed criteria

Local involvement

- open facilities for use by parents and community members
- further existing mentor relationships with local businesses and develop new ones
- develop virtual partnerships with cultural institutions, community resources and government officials

Professional development for teachers

Middletown City's philosophy on teacher training is that teachers learn best from teachers, especially those with whom they work closely; a core group of trainers that include two teachers from each of the six academic teams and specialized teachers (e.g., health, phys. ed., special ed.) will participate in the initial training. These teachers will participate in weekly technology training comprised of basic computer/technology skills, how to operate certain software and how to integrate the technology resources provide by TLCF funding into the daily curriculum. They will then be responsible for teaching their interdisciplinary team colleagues what they've learned.

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[Montgomery County Public Schools] PREV UP NEXT [Milwaukee Public Schools]

Milwaukee Public Schools

Wisconsin

Milwaukee Public Schools
HOMEPAGE

Milwaukee Public Schools (MPS) is in the midst of major high standards and reform initiatives. New high school graduation requirements, middle school proficiencies, and soon to be developed elementary school proficiencies, have generated a sense of urgency and momentum surrounding student achievement and school accountability. MPS is using a standards based, rigorous curriculum, with an assessment package that includes state standardized tests, district performance based assessments, portfolios, and classroom based projects. These and other changes in urban education, require new and innovative teaching strategies and the use of technology for instruction, assessment, and management of student information.

There has been a tremendous mobilization of energy and resources to prepare staff and students to meet rigorous high standards. The focus is on student-centered learning environments that use technology to Support student's individual needs and capabilities. Changes in the curriculum that stress higher order and critical thinking emphasize the use of technology as a tool for teaching and learning rather than an entity in and of itself.

Technology support strategies include infrastructure requirements, decentralized management, school accountability, professional development, collaborations, and fiscal support. The district Technology Strategic Plan delineates the process to provide every school in our district access and connectivity. Decentralized decision making and budgeting allow all schools a voice in how rapidly they acquire hardware, software, and professional development. Clearly delineated academic outcomes and targets with appropriate assessments provide the incentive for a high level of accountability. Partnerships within the community including businesses, community based organizations, foundations, institutions of higher learning, and grant funding, have supported the continual use of technology across the curriculum, across settings, and as a vehicle to extend and enrich the learning experience.

The MPS Technology Plan makes it possible to facilitate learning environments, anytime anywhere, with anybody. Various projects have utilized this philosophy, including Technology Literacy Challenge Fund (TLCF) professional development, the Connected Community of Learners (CCL) project, and Goals 2000 Grant. Teachers employing technological tools for distance learning and on line instruction, have brought about the kind of teacher leadership that has resulted in high level student projects, teacher collaboration, integrated clinical approaches, and sophisticated approaches to assessment.

The Replicable Schools Program is an important model for the integration of technology at the classroom level. Like the TLCF initiative, teachers receive ongoing training and support and are given the opportunity to network, model, and train other teachers. Both programs are examples of the systemic commitment to meaningful professional development and the direct connection to the classroom. The focus on academic achievement, efforts to increase access, researched based decisions, and extensive professional development, are the key elements of Milwaukee's technology implementation.

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[Middletown County Schools] PREV UP NEXT [New Haven Public Schools]

New Haven Public Schools

Connecticut

New Haven Public Schools
HOMEPAGE

PURPOSE:

To develop teaching teams who can train other teachers to use the Internet as a curriculum resource.

DESCRIPTION OF PROJECT:

Interested candidates met at an information session to take a pre-test and see models of the products they would be asked to create. Two participants from 44 sites (including 8 private and parochial schools and the Public Library), where one participant was the school LMS, were selected for four days of training the first year, and five days the second year. Through training at our Regional Educational Service agency for the county, ACES, teams of teachers and library media specialists have created a professional development website, including a curriculum-related project that utilizes resources from the World Wide Web. Projects demonstrate participants' experience with Internet search strategies, the identification and assessment of appropriate curriculum-related websites, and website development. Each team trained other teachers at their schools, using their website projects, which are published on the Web through the use of FrontPage98. Through a strong focus on the integration of the Internet into the curriculum, participants earned many other computer skills, such as word-processing, creating and utilizing electronic images, desktop publishing and multi-media integration.

GOALS for the second year of training (in terms of Expectations)

At the end of the 5 sessions, participants will:

- Develop search strategies on the Internet.
- Demonstrate how to identify and assess curriculum-related websites.
- Create a website with FrontPage98 that can be a useful tool for professional development.
- Select and publish a list of curriculum related websites for one or more teachers in the school (as part of their professional development tool).
- Create and publish on the WWW a curriculum project with FrontPage98.
- Use what they have learned and created to provide professional development to members of a school staff.

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Norman Public Schools

Oklahoma

Norman Public Schools
HOMEPAGE

In the fall of 1993 the Norman Public Schools formed a 28 member Technology Planning Committee. Membership included parents, members of the community, teachers and administrators. Issues addressed included instruction, staff development, management and funding. The Committee developed a vision for technology and goals for the implementation of the vision:

Vision statements were included for "Technology and Learning", "Technology and Teaching", "Technology and Assessment", "Technology and the Community", and "Technology and the Work of All District Staff".

Goals include:

1. Establish a computer communications network for the purpose of information access and sharing among classrooms within a school and among schools within the district, with parents and the community, and among district personnel.
2. Establish a video production/delivery network for the purpose of instruction, information sharing and information access.
3. Assure equity of access, opportunity and experience for all teachers, students, parents and members of the community through technology.
4. Establish the library media center as the technology hub of each

Instructional site.

Since 1994 a great deal of progress has taken place:

Training: Staff development is key in integrating technology into the curriculum. The Norman district has developed a cadre of teachers called Pro Teachers for Technology, obtained grants to develop and staff a Technology Training Lab, and developed NPS Technology Day which has become a statewide professional development conference. Sites develop technology goals as a part of their site plans for school improvement and plan technology training. A full schedule of technology training is offered by the district focusing upon integration of technology in the classroom and stipends are paid to teachers for summer participation.

Access to Hardware and Software: Bond funds, Title I funds, PTA contributions, various grants and the district general fund have supported access to technology in this district which operates with less than the state average in per pupil expenditure. Access to computers has more than tripled; instructional software, including integrated learning systems at some sites, is in place. A "Unified Desktop" design (district standard) provides password entry to a system that combines a full PC workstation with the capabilities of network computers.

Connectivity: A wide area network begun in December of 1995 (fiber provided by the cable television company) now connects every school and LANs connect almost every classroom - will connect every classroom by the fall of 1999.

Technology Support: Standardization of software and hardware, extended warranties, outsourcing contracts, and a team approach to technology support were put in place in 1998 to facilitate efficient technology support. The team approach combines the resources and abilities of the Information Systems and the Instructional Technology departments.

Although the district technology plan has been updated since in was put in place in 1994, work on a new plan with a more focused instructional emphasis will begin in the fall of 1999.

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[New Haven Public Schools] PREV UP NEXT [Ohio County Schools]

Ohio County Schools

West Virginia

In November, 1992, the Ohio County Schools Technology Implementation Committee was charged with studying the current and future technological needs of the school system, as well as developing an implementation plan for the effective use of technology in instruction and administration.

This charge resulted in the development of "Technology: Our Future Now - A Five Year Plan and Beyond". This initial technology plan served as the basis for implementing the hardware, software and infrastructure throughout the system.

The funding for this project was realized through a bond levy that was approved by more than 70% of the voters. The initial implementation was phased in over a five-year period. Some of the highlights of this implementation are as follows:

- appointment of a district technology coordinator
- continuation of the technology committee
- designation of building technology specialists
- infrastructure development (cabling plan for all classrooms)
- placement of four workstations and a printer connected to the school-wide network in all classrooms
- implementation of WVEIS (West Virginia Education Information System) for administrative management
- provide for staff training (instructional and administrative)
- replacement of existing phone system, providing for voice processing at all locations
- installation of FAX machines in each building
- purchase of appropriate software

As the technology plan was a dynamic document, it was revised and updated by the committee. In addition to the original implementation, the Bell Atlantic World School Project was supported. This project provided internet access to all schools via a 56kB Cisco router. Two other statewide projects also were implemented. The Governor's Basic Skills Program provides for software and hardware in grades K-6. The WV-SUCCESS (Student Utilization of Computers in Curriculum for the Enhancement of Scholastic Skills) is now in its third year. This project provides internet computers in grades 7-12, along with office suite and career exploration software.

In addition, Ohio County is actively involved in local, state and federal grant programs. Examples of these include:

- CTRC program, which has provided multimedia laptops and training

- Telecommunications/Technology grants that have provided additional internet computers
- Infomine Project for accessing library databases
- TLCF (Technology Literacy Challenge Fund) Grants
- Partnership with local TV station to provide for an internet weather station
- School Technology Team training
- Partnerships with local colleges and universities to provide staff development
- Phase 9 Training through the High Tech Consortium in Fairmont

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[Norman Public Schools] PREV UP NEXT [Okaloosa School District]

Okaloosa School District

Florida

Okaloosa County Schools
HOMEPAGE

The Okaloosa School District has a comprehensive plan for technology which includes technology infrastructure, teacher training, access for students and instructional software. The following is an overview of these areas of technology:

The District has an Okaloosa Metropolitan Area Network (OMAN) and each school has either a T1 or 56KB line. We have two T1 lines for Internet access, one provided by the State of Florida FIRN network. The District also has a BESS Proxy Server from N2H2 that filters unwanted Internet sites. All schools have as a minimum 10 Internet lines in either the media center or a lab. This gives access to the Internet for all students. Many schools are completely retrofitted for voice, video and data. During the next 5 years, the rest of the schools will be retrofitted.

The State of Florida has developed Sunshine State Standards for students. These standards have technology woven throughout them. The District selected Student Standards for Technology from the Sunshine State Standards. Based on the student standards, the District developed Basic Technology Competencies for Teachers. This is what teachers need to know in order to teach the students. Training for basic competencies if provided through school-based mentors, District trainers, and other modes of training. The District has developed a model for training teachers to integrate technology into the curriculum, TOOLS 2000. In this workshop teachers learn basic computer skills, use of a digital camera, instruction on the writing process, technology based activity centers, theory of multiple intelligence, authentic assessment using a rubric, managing a classroom with technology and planning thematic units. The workshop has been very successful and is now being piloted online for teachers to take from school or home. The District has implemented an incentive program called Top Notch Teacher. When teachers complete basic competencies, take a test on them, and show by means of a portfolio that they are integrating technology into the curriculum, they receive three new computers for their classroom.

Through grants and State Technology funds the Okaloosa School District and schools are purchasing instructional software programs for students. This year two elementary schools received a TLCF grant for reading. Computer Curriculum Corporation reading software and Lightspan Home School programs were purchased. One of our high schools received a TLCF grant to implement a two-year Algebra I class to assist students who normally don't take Algebra. The State recently required that all students complete Algebra I. The District also received a TLCF grant for distance learning and instructional television, Best Practices in Action. In this grant, a tower is being constructed in Bay County that will connect all the counties in the Panhandle for instructional television, put the TOOLS 2000 training online and produce training and parent awareness videos for technology.

As you can see, there is a lot going on in the Okaloosa School District. We are proud of our

accomplishments and are looking forward to the future with technology as a tool for learning.
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[Ohio County Schools] PREV UP NEXT [Oswego School District]

Oswego School District

New York

Oswego School District
HOMEPAGE

Short Description

The Oswego school district's technology program has accomplished what others have failed to do. It enhances teaching and learning through an enterprise-wide system that includes a reliable network, strong staff development, and web-enabled instructional materials, assessment, and training.

Long Description

Earlier this decade, school districts around the nation began hearing about the power and promise of using information technology to improve teaching and learning. Many went on a buying spree, cobbling together the public and private resources necessary to wire their schools for connectivity to the Internet and to equip classrooms with computer terminals.

Today, many of these districts have unprecedented access to technology. Most, however, have not demonstrated that they have the means to use the technology to improve learning. As a result, 95 percent of the instructional technology programs implemented in districts have not lasted more than three to five years, studies show.

Oswego, with 415 teachers and 5,600 students - nearly 40 percent of whom live in poverty - is different. Despite a shrinking property tax base, the district has been able to sustain and build an impressive enterprise-wide information delivery system that fully integrates a network, instructional and communication materials into teaching and learning. Further, the system is: 1) used and understood by teachers and students; 2) continually updated to avoid obsolescence; 3) driven by the needs of teachers and students, not by the needs and desires of outside vendors; and 4) fully integrates a network, instructional materials

The district owes much of its success to careful planning. Drawing on the recommendations of teachers, parents, school board members, business people and community leaders, Oswego has developed and implemented a five-year strategic plan that has helped turn skeptics and technophobes into technophiles. Following are the major features of the system:

To ensure that teachers understand how to use the technology, Oswego equips a classroom with computers only after the classroom's teacher participates in extensive training. The training includes 27 hours of instruction on Internet access and 30 hours on basic computer skills. Only a handful of the district's 415 teachers have not participated. The average teacher has taken more than 130 hours of instruction; in some schools teachers have taken as many as 250 hours. More than 50 courses are offered.

And because most software manuals are written for business users, the district customizes and writes its own manuals so that examples are relevant to the classroom.

Oswego commits 2 percent of its budget to support technology each year. The investment allows Oswego schools to replace 15 to 20 percent of its equipment annually, thereby preventing obsolescence. In addition, the district has received hundreds of thousands of dollars from private sources and vendors through donations and in-kind services.

The district has two full-time technicians who staff a central help desk. In most cases they are able to diagnose and correct problems remotely over the network, obviating the need to travel to schools and interrupt classroom instruction, or the need to turn teachers into computer technicians, allowing teachers to focus on instructional integration. Redundant systems keep the system running, even when pieces of it shut down.

Oswego uses a district-wide area network (WAN) as a backbone for its technology infrastructure. The network links all district buildings to each other and to the Internet. Fiber-optics are used to distribute data to the buildings, guaranteeing high bandwidth and fast throughput and allowing rapid access to network applications, and internal and external information sources. Within the buildings, data is distributed to the classroom over category 5 cable at a rate of 100 megabits per second.

Each classroom is equipped with four student workstations, one teacher workstation, and printing and classroom-wide viewing capabilities. The configuration assures all students relatively easy access to the Web. In all, 2,000 Compaq PCs in eight separate school houses, a district office, a transportation center and a warehouse are linked by a high performance network of Compaq computer servers, supported by Windows NT server software.

Because a system is only as good as the information it carries, Oswego spent considerable time and effort surveying other model districts. The research helped the district select an extraordinary array of instructional resources that it delivers to every desktop of students, teachers, staff and the community.

At the click of a mouse, students can access local library collections, a huge volume of online resource materials and a number of different research and curriculum applications to support teaching and learning. Teachers can share information on student assignments, curriculum resources and professional enrichment activities. They can link to technology tools and manuals and use e-mail to communicate with their colleagues and students.

Many of the same resources are available to parents and community members. They also can review student performance data, lunch menus, calendars, news about the district and academic standards.

In sum, many districts aspire to build a global schoolhouse; Oswego has succeeded. It is no wonder then, why 67 school districts from around the U.S. and Asia visited the Oswego City School District Technology Program during the 1997-98 school year alone.

Benefits

Anyone who logs on to a personal computer in an Oswego classroom, kindergarten through 12the grade, cannot help but recognize how technology has fundamentally redefined the way students learn and teachers teach in the district.

For all K-12 students, the desktop allows access to the following:

- All the resources of their school and city libraries
- A periodical database that covers 800 online publications, including Congressional Quarterly, an on-line dictionary and thesaurus and six different encyclopedias -- World Book On-Line, Encarta 98, American, Grolier, Compton's Interactive and the Ultimate Children's Encyclopedia;
- Access to topic-related databases available through several commercial providers, including Electric Library, SIRS Researcher and ProQuest;
- Access to Web search engines, including Yahoo, AltaVista, Excite, HotBot, InfoSeek, Lycos, and N Light
- A number of newswires and network news services, including AP, Reuters, Bloomberg, ABC, CBS, CNN, Fox, MSNBC, NPR, ESPN and the Weather Channel
- Regional and national newspapers, domestic and international magazines arranged by subject or country of origin, and domestic and international trade publications

Students have at their fingertips such tools as Microsoft Office, Publisher, Adobe Photoshop, LogalMath Science and Computer Curriculum Corporation's Video intensive instructional Learning System.

In addition, students can access GaleNet, a comprehensive database that includes: 440,000 nonprofit membership associations, as well as brochures, and descriptive materials for 2,500 of these organizations; 282,000 consumer brands and 51,000 companies that manufacture them; complete biographical and references and information on 100,000 contemporary U.S. and international authors; critical essays on contemporary authors; student-focused materials on most studied authors, biographies, science and history topics and multicultural issues; student-focused materials on Shakespeare, poetry and world history; several of the most popular college guides; and a database of publications and broadcast media.

Beyond the rich list of library resources, students can take grade- and subject-specific practice quizzes and play educational games to improve their skills. In many cases, these quizzes and games are designed and posted by their teachers using off-site software developed at the University of Hawaii.

Students also can connect to a vast array of off-site programs designed to improve skills. For example, they can link to the Math Forum, an on-line tutorial service, located at Swarthmore College, for students in elementary, secondary and post-secondary schools. They also can link to National Geographic, Cyber Seuss, the Electric Zoo and other on-line services that educate and entertain at the same time.

Students can post and view PowerPoint projects developed by them and their classmates for classroom credit. The projects are posted by student name, grade and topic. Subjects covered in the presentations include everything from African art to movie reviews and Shaq O'Neill.

The district is currently developing a site that will offer students study guides and materials to prepare them for the New York State Board of Regents exam. As is the case with many locations on the Oswego desktop, this site will include material developed by teachers as well as students. For example, as part of a class project, students already have developed a site called "Great Cases of the Supreme Court," which will help prepare readers for the government section of the Regents exam. Another site developed by a technology consultant who works for the district includes a subject-specific bibliography of teacher resources, student activities and references that will help prepare students for the Regents exam in chemistry.

For students as well as teachers, a technology section of the desktop contains a variety of Web site development tools, including tips, tutorials and multimedia files. Examples of sites developed by students are also posted. The technology section gives teachers an up-to-date list of available in-service professional development courses to improve their technology skills.

Teachers can review curriculum materials posted on the site and, using a search engine, hunt for these materials by subject area, resource type and grade level.

It is clear from viewing the desktop that the level of teacher participation is deep. One page lists dozens of subject guides developed by Oswego teachers and posted for their colleagues and for students. They include a step-by-step guide for writing research papers, guides to literary terminology, roots and prefixes, parts of speech, composers, trinomial factors, Spanish and French vocabulary lessons.

Through an on-line service called CCCnet, teachers also can access outside resources for up-to-date curriculum materials, mentors and subject-specific topics. CCCnet also offers students study materials in math, science, social studies, reading and language arts.

These resources, and more, have changed how students work and demonstrate their competencies. In their subject areas they have ample opportunity to show what they know with games, quizzes and projects. In addition, students master the fundamentals of making presentations with PowerPoint, creating text documents with Word and building relational databases with Excel. They use such powerful desktop software as Microsoft Publisher, Adobie Illustrator, PageMaker, Photoshop and Acrobat. More than 65,000 clipart images are available to students through various databases.

Because students have high bandwith access from workstations, they essentially replace six- or seven-year-old textbooks with virtual textbooks that can be updated with a stroke of the keyboard.

For teachers, the technology solutions are changing not only how they teach, but the way they communicate with each other. Until recently, teachers in Oswego were no different from teachers anywhere else: They tended to be isolated from their peers. The new technology, however, gives them opportunities to share information and promising practices not only with other teachers in their building, but also with teachers elsewhere in the district, the state, the nation or the world. They can take ideas posted on their desktop and implement them as they are, or change them to suit their teaching style or their students' needs.

Importance

Information technology has changed the business of education by placing entire libraries of material at students' fingertips. Students who otherwise might be turned off by material in a book eagerly follow leads and links that allow them to leap from one island of information to another, coupling the challenge of a puzzle with the joy of discovery.

Similarly, students who might be loath to pick up a pen to write an essay can become authors, artists, and animators using word processors, graphics software and presentation programs to do their projects. This can be demonstrated by a high school student who won the ESPY Writing Award in 1997 and attributed his success to the technology located in the high school writing center.

But just as the young seem naturally inclined to embrace the new technology, their teachers sometimes do not share this enthusiasm and lose interest in working with a tool for which they were not properly trained.

Oswego's goals were:

- Bring teachers up to speed on the new medium and keep them there
- Migrate learning from paper and blackboards to electronic media
- Develop a system that would serve as the students' guide to help them find what they seek

This last point is crucial because while students may initially enjoy working on a computer, it can become a frustrating experience if they are unable to find the material they need to do their work. That is why the school district's network is laden with pointers, tips, material, links, search engines, resource materials, and database access.

The network provides a similar range of resources to help supply teachers with the tools to do their work and to allow them to communicate with each other. The network's resources receive constant attention and updating. It is not treated as an afterthought.

Oswego recognizes this as the tool that it is, and everything about it is directed toward the purpose of education.

Originality

The Global Schoolhouse was conceived and built as an integrated system to serve the educational needs of its teachers and the learning styles of its students. It was not jury-rigged to fit around existing pieces. The network in Oswego is built to accommodate the needs of educators, and the pieces that rely on the network were designed to work with it. For example:

- The network hardware was designed to connect remote campuses with high-speed, redundant systems to ensure reliability and convenience.
- Teachers have strong incentive to train themselves The training teachers and staff receive assures that they will use the system wisely and efficiently.
- The manuals teachers and staff use in their training cite examples that resonate with educators. They describe what teachers will experience in the classroom and what they will experience on the network.
- The educational software delivered to students works well on the network, and serves the instructional needs of teachers as well as the educational needs of students.

The way students use the technology is different from the way it's used in many districts. Oswego has established what it calls "electronic learning environments" -- classrooms where every student is equipped with a desktop computer. The learning that occurs in these rooms is completely linked to instructional technology.

The manner in which Oswego uses its resources also is different. From the very beginning, the district recognized that it did not have money to burn, time to lose, or human resources to squander. Oswego bought what it had to, foraged for good ideas from other institutions, and scrounged for quality material that is available free over the Internet. The district established partnerships, benefited from corporate generosity, and did a lot of legwork on its own. It used others' partial solutions to create a whole system.

For example, teachers avail themselves of free online quiz makers so their students can take customized, electronic tests. Teachers put up their own Web pages to give students tips on topics, such as how to write a research paper. The district planned carefully, shopped wisely, and worked hard. Teachers were brought into the process early and continue to spearhead the effort.

The result, in the end, is one integrated system that helps the teacher provide enhanced learning opportunities for students.

Success

The Oswego district has met and exceeded its goals for professional development and use of the network by teachers, students and the Oswego community in general. Outside evaluators have concluded that the district has accomplished in one year what many expected would take three years.

The district set a first-year goal of reaching 35 percent of its faculty and staff in professional development programs for integrating technology into the classroom. Instead, 85 percent enrolled. As of today, 99.6 percent of teachers and staff have taken the requisite number of courses needed to qualify for technology access. Four staff development rooms, each seating 40 teachers and operating four nights a week, are filled to capacity.

High volume use of the system is evident. The T1 Internet connection is so saturated that the district is now evaluating the use of a segmented T3 connection. Put another way, the district currently has 1,200 of its 2,000 computers active during any given moment of the school day. Since June 1998, more than 36,500 have visited the district's Web site, which suggests heavy use by the district as well as people around the world.

Use of the system is expected to double each year over the next three to five years. In many districts, where small LANs and numerous administrators are the norm, such growth would be problematic. But Oswego, with its Windows NT network and centrally-located servers, is ready to support the expansion.

Elementary school students in Oswego are miles ahead of children their age group in technology skills. First and second grade students are using electronic resources to research thematic units and communicating what they've learned through a Microsoft PowerPoint presentation or the creation of a Web site.

Students interested in drafting or engineering careers are becoming adept at AutoDesk computer-assisted design, drafting and manufacturing. Those who take three sequences of AudoDesk courses are qualified to take the AudoDesk licensing exam. If they pass, they can compete for jobs earning $35,000 a year. Similarly, the exposure of high school students to the Microsoft Office suite is helping some pass the performance exams for Microsoft certification.

The district's digitally equipped television studio is giving students hands-on training in communications fields. William Bellow, an instructor in the communications studio, says 22 students who graduated from his course last year were accepted into college communication programs. "Ninety percent of these kids ultimately are graduating from the college communication programs they enter," he says. Bellow says some of the more competent graduates are anchoring local television news shows or are working in the Learning Company and The Children's Television Workshop. Oswego Communication students leave competent in industry standard equipment and software such as: 3D-Max, Alladin, Character Studio, Inscriber CG, non-linear editing, digital cameras/decks and telescript. Oswego also boast the only Regents approved Communications Major in new York State with all of its college-bound students entering communications programs in some form of advanced standing.

Examples abound of teachers who are personally benefiting from the technology focus. Thomas Caswell, a third-year social studies teacher at Oswego's high school, came to the district with no special skills in technology - he didn't acquire his own personal computer until 1997. Today, using distance learning, he is earning a master's degree in instructional technology. He is one of 25 educators in the country nominated and recognized for his exemplary integration of technology into the curriculum.

Julie Burger, a second grade school teacher, has completed nearly 200 hours of inservice technology courses. Her students create reports using Microsoft Word, digital cameras and the Internet. "Students in my class have typically been successful," she says. "I never realized though how much deeper their understanding and knowledge could be until I started using technology in my class. There has been a dramatic change in how much better and faster my students learn with our technology."

Outside organizations have recognized Oswego's progress. Microsoft cited Oswego in 1997 as a creative and innovative school. Digital Equipment Corporation gave the district its Master of Innovation award this year. And Compaq Computers says Oswego is in the top 5 percent of districts in the country that have integrated technology into the curriculum.

"Our close association with the Oswego School District has provided us with a solid example of how leading-edge technology, backed by vision and drive, can produce compelling results," says Susan Twombly. "By augmenting traditional teaching methods with the practical application of the latest technology, they are truly innovators in education."

The district plans within the next two years to add five more elements to the technology mix: 1) access to curriculum servers from teachers' and students' homes and remote locations either by cable television or modem dialup; 2) a video distribution system; 3) video on demand to support instruction; 4) electronic lesson plan files; and 5) a Windows-based student accounting and record-keeping system.

Difficulty

School districts typically encounter the following problems: they put computers into classrooms without showing teachers how to use them to improve learning; they plan for today, rather than the future; and they rush to judgment on technology solutions to satisfy the political demands of policymakers who need to assure the public that the district is *doing something*.

Kenneth W. Eastwood, Oswego's assistant superintendent for secondary education and technology, says his district initially fell into the same traps as other school systems. In 1991, after substantial investment, its teachers and students had little access to computer labs, teachers had little or no training in how to use the equipment, and few had figured out how to make computers relevant to their classrooms. As much as 85 percent of the technology was already obsolete, and no long-range plan existed for sustaining the technology effort.

Oswego began reversing its course when it decided to commit to a strategic plan that would make technology the slave to instruction, and not the other way around. "Schools typically get the boxes, then do the planning," Eastwood says. "We identified the needs, solutions and then talked about the technology before we spent a nickel on it."

The strategic planning process, which began in 1994, identified the expectations of parents, teachers students and the local business community. Further, to assure that its technology plans truly suited teachers' instructional needs, the district took information it gathered from interviews and used it to develop a survey instrument to poll teachers on classroom needs. Responses were received from 95 percent of them.

The planning process helped create a critical mass of support for technology in the classroom. It also helped define the infrastructure the school would use. And because so many people were consulted, the process helped create buy-in for funding from critical stakeholders.

Nevertheless, in some school buildings principals emerged as obstacles to technology because of a combination of their age and lack of exposure. The district opted to go directly to the customer -- the teachers. It told teachers they could act on their own to acquire instructional technology in their classrooms; all they had to do was take the requisite number of professional development courses.

As a result of these strategies, the district was able to overcome resistance and obstacles. Today most residents of Oswego are proud of their schools' technology system and are users of it.
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[Okaloosa School District] PREV UP NEXT [Richland School District #1]

Richland School District #1

South Carolina

Richland School District One covers 482 square miles and serves the capital city of Columbia, South Carolina encompassing urban, suburban and rural neighborhoods. A diverse student enrollment of 27,000 students in 51 schools and an equal number of adult education students, give the district its character and strength.

Richland School District One has embarked on a significant, aggressive plan to acquire, support and use technology throughout schools and the community. The establishment of the Information Resource Management Department in 1995, combining and expanding the former Educational Technology, Media Services, and Electronic Repair Units, signaled the beginning of the district's focus on the integration of technology in the instructional arena.

The successful 184 million-dollar bond referendum in 1996 enabled the district to support new school construction, school renovation and renewal and the establishment and expansion of the district wide technology infrastructure. A three year, four-pronged infrastructure plan, funded by the bond at 9.23 million dollars, was initiated in the spring of 1997 that:

1. created the wide area network with Internet access at all locations
2. expanded all school LANs to all classrooms
3. replaced file servers in every school
4. placed two additional computers in every classroom and 15 computers in every media center.

Coupled with these initiatives was the expansion of the technology education program. Courses, modules and workshops offered throughout the school year and summer months are keyed to the district's technology competencies that all employees are expected to master. District-level instructors are full-time technology educators experienced in technology training and integration. Classroom teachers who have demonstrated skill in using technology effectively provide training for evening and summer courses. Additionally, media specialists provide training during and after the school day.

Supplementing the district's technology implementation is a five-year, 4.3 million-dollar Technology Innovation Challenge Grant awarded in October 1997. The grant, titled *Richland Clicks!* focuses on improving student achievement and community involvement through technology. A wide array of grant activities provides a comprehensive approach to using technology as a tool. An instructional website, curriculum connections lessons, laptop lending program, technology van, and strong community partnerships define the scope of the grant.

Richland One is a beneficiary of state-level initiatives focused on enabling school districts to move forward with successful technology programs. Funded by the state legislature, and administered under the direction of the State Department of Education, millions of dollars have been appropriated to establish infrastructure, Internet and telecommunications, purchase hardware and software, and support the professional development needs of educators. A recently revised State Technology Plan, curriculum frameworks, achievement standards and regional technology centers increase the depth of resources to meet local needs.

Much has been accomplished in Richland One in a few short years. Preparing our students, parents and community for the future will continue to challenge our skills and creativity.

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[Oswego School District] PREV UP NEXT [Roy Municipal Schools]

Roy Municipal Schools

New Mexico

The Roy EPSS (Educational Plan for Student Success), a New Mexico Department of Education mandate, is an integral, yet changing part of the Roy educational system, technology in particular. New Mexico EPSS is an attempt to align local and state standards and benchmarks with national education goals including: CITE -- Consolidating Initiatives for Tomorrow's Education, New Mexico Standards of Excellence, President's Educational Technology Initiative, and Roadmap to School Improvement. Everyone is involved in the Roy community, students, businesses, faculty, administration, and families. Everyplan, action, activity, and evaluation is tied to our EPSS.

The turning point for our technology plan was the implementation of the EPSS in 1995 which proved to be the driving force in the integration of technology into the curriculum. Prior to 1995, there were several computers and printers in place. However, there was not a long range strategic plan providing for focus and direction. We lacked qualified personnel with the experience and knowledge necessary to lead our school into the technological millennium. The administration and faculty through community input realized that although we had the hardware, something was missing. Parents, teachers and students wanted to be able to use technology.

Technology, at this time, was limited to basic computer games and word processing with high schools students having primary access. The school's resources were not adequate to address the technological needs of the Roy students. The success in acquiring grant funding and a clear vision has enabled our school to provide state of the art technology including ACAD, Multimedia studios and labs, voice recognition capabilities, networking, 21 CD ROM tower, schoolwide computerized grading system, individualized education and career planning, website design, and Internet explorations.

To insure the success of technology across all subject areas and grade levels, an integrated technology curriculum was written by students and teachers. As a result, technology has become the norm by everyday use of hardware and software available. Integration of technology has consolidated the efforts of teachers and students to result in outstanding projects satisfying academic requirements of more than one teacher across curriculum.

Our system was inadequate to meet the demands of the students, faculty, and community needs. Additional grant moneys were awarded to implement programs to satisfy students' needs and to allow our graduate to be very competitive.

Our exceptional technology program located in a remote and rural area has grown to be an exemplary model for New Mexico schools.

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[Richland School District #1] PREV UP NEXT [S.A.D. #4]

S.A.D. #4

Maine

S.A.D. #4
HOMEPAGE

The S.A.D #4 Technology Committee has met on a regular basis for the past two years in developing and revising, the district's comprehensive Technology Plan.

The Committee is comprised of the Superintendent of Schools, Guilford Public Librarian, Guilford First Selectr ıan/Technology Consultant, Community Education Director, Special Education teacher, three classroom teachers (high school, middle school, elementary school, and three administrators (high school, middle school; and elementary school.)

The Committee has conducted staff surveys to help establish priorities for staff development and determine levels of effectiveness in classroom integration The school board's Curriculum Committee has engaged in establishing goals, action strategies and evaluation guidelines.

The S.A.D #4 plan highlights key areas of progress for our district:

- Training 75% of the K-8 staff in utilizing technology effectively in the classroom.
- Purchasing one hundred new computers for K-12 in the past twelve months. Establishing a fiber optic 5-1 2 system with T 1 access for Intemet access.
- Providing telephone, E-mail and Internet access to all classrooms in S.A.D # 4
- Establishing a comprehensive district Web Page.
- Providing extensive summer and after-school computer activities for K-6 students.
- Establishing a K-12 "data strategies" approach to managing student's continuous progress on Maine's Learning Results.
- Invited to serve on the initial State of Maine Distance Learning Project
- Selected by the State of Maine as the representative at a national conference on the "Effectiveness of Technology in Teaching."

The S.A.D. #4 Technology Plan combines past experiences, current practices and a vision for the future.
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[Roy Municipal Schools] PREV UP NEXT [Sherman Elementary School]

Sherman Elementary School

West Virginia

At Sherman Elementary School technology is incorporated in our curriculum in a number of creative and innovative ways. Our school has four Jostens Basic Skills Computer Labs that children in grades Kindergarten through Six work in daily through the departmentalization of classes. The Jostens Basic Skills labs promote reinforcing and reteaching of basic reading, math and writing skills. Children work at computer stations on their own level and at their own pace to review basic skills daily. Teachers place students on appropriate levels with the Basic Skills Inventory (BSI). The computer lab teachers are also able to track students' progress with several reports the program generates. Our Fifth/Sixth grade computer lab has recently been upgraded with ten new IBM computers, programmed with Compton's Encyclopedia, Office '97, and the *Tomorrow's Promise* program. This was accomplished using funds received from the Technology Literacy Challenge Grant and with funds from Boone County Schools. Sherman Elementary plans to completely upgrade this lab with additional computers purchased with Budget Digest Grant Funds through the office of WV Senator Lloyd Jackson. Our Preschool children will benefit from this grant funding by allocations for the purchase of new learning software for the Preschool Computer Lab.

Sherman Elementary staff will be trained in the use of *Power Point* technology to enhance lessons and for presentations on local, state, and national levels. Plans are now also being made to purchase the Accelerated Reader Program through funds from grant writing sources, Business Partners and school/community funding. Accelerated Reader is a computerized reading program and with the STAR database program tracks students' progress and reading growth. This program will enhance our current reading program at the first through sixth grade levels and allow students to progress at their own pace.

Children at the Fourth, Fifth and Sixth grade levels participate in our Higher Order Thinking Skills (H.O.T.S.) Computer Lab. The H.O.T.S. classroom is a computer lab with 13 new Internet accessible IM computers equipped with Compton's encyclopedias, a trained H.O.T.S. teacher and a H.O.T.S. Aide. This computer lab is unique in that it utilizes technology to promote positive self-concepts and to increase higher level thinking. The program targets priority students, but all Fifth and Sixth graders utilize the lab once a week.

Sherman Elementary offers parents an opportunity to take-home computers with our Take-Home Notebook Computer Program. Windows 95 and the Emerging Literacy Program Training are offered three times a year for the notebook computer program. Parents are trained in a daylong training, on the use of these programs to assist their children in learning. This program is exceptional in that it was created by Boone County's Title 1 Director, Carolyn Miller. Another innovative program Sherman Elementary offers is the Lightspan Program. This program utilizes Sony PlayStations as a tool for learning, along with interactive software in a game format for Language Arts, Mathematics, Science and Writing. Family Training is provided throughout the year for parents who wish to work at home with their children. The PlayStations are also used in the Title 1 classrooms for instruction and reteaching.

Sherman Elementary' Comprehensive needs Assessment (CAN) is conducted using computer technology. Information gathered from our need assessment, such as standardized test scores, is logged and stored on the Sherman Elementary Title 1 Needs Assessment Database. This database was created by a member of our school community, Bruce Williams, who is principal of Whitesville Junior High School. Our school's Unified School Improvement Plan highlights our Use of Technology, Technical Assistance, and Support Plan along with our current Technology Infrastructure Diagram. This document is updated yearly in conjunction with our Local School Improvement Council, Principal, Technology Team and staff.

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[S.A.D. #4] PREV UP NEXT [South Harrison Community Schools]

South Harrison Community Schools

Indiana

Prior to 1994, technology was the responsibility of the school's principal. The money for technology, then called computers, came from the school's operating budget. Principals purchased the equipment, placed it in the classrooms, and the teacher decided what to do with it.

South Harrison hired a Director of Technology in 1994. It would be the responsibility of the Director to develop a technology plan; purchase, install, and maintain equipment; train the staff; and create policies and procedures. A District Technology Committee was formed and a five-year plan created. The plan contained policies, procedures, criteria for hardware and software selection, and a plan for implementation.

The first three years, the focus was on acquiring hardware and software. Office networks were created in the elementary schools and the two secondary buildings were wired to every classroom. Elementary classrooms received small pods of computers while secondary schools focused on lab settings. Word processing and content driven software was the norm.

The third year of implementation some major adjustments were made in the approach to technology usage. The technology was becoming more powerful. Creation, production, and presentation software were emerging. Multimedia added a new dimension. Teachers and the Director of Technology were disenchanted with the "drill" based software. It was felt that this software was not making a difference in improving student learning. Students discovered ways around the software without focusing on the skill, or the student became frustrated when he/she could not master the skill and the computer was insensitive to the student's needs. The focus for software selection changed from content based to technology as a tool.

With the change in focus for software and application, came a change in the methodology for implementation of technology. Labs, even at the secondary level, would be limited to only content areas that required computers such as autocad. Other labs would be dismantled and moved into classrooms.

In the most recent years, the focus shifted from hardware and software to connectivity and professional development, not that hardware and software are forgotten. Grant monies have enabled South Harrison to be able to continue hardware and software implementation while building the networks and providing professional development. The Corydon Campus schools were connected in one network. The South Central Campus schools were connected in another network. The next phase is to connect the two campuses and bring the two outlying elementary schools into one network.

A cadre of teachers was trained to be teacher trainers. Release time, Saturdays, and summer workshops have been provided extensively over the last school year. Placement of mini labs in secondary classrooms required a change from traditional whole class instruction. The professional development needed to address more than "how to" manipulate the technology. The workshops were designed to assist in connecting all the pieces. Curriculum, instructional strategies, alternative assessment, and classroom management using technology as a tool to improve student learning by engaging the learner in authentic project based learning became the focus of all professional development.

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[Sherman Elementary School] PREV UP NEXT [North High School]

North High School

Wichita Worth County Schools
Wichita, Kansas

North is an urban school in a large school district. There are 1,600 students and 56% of them are from disadvantaged homes. The school is culturally diverse with 3% Indian, 6% Asian, 19% African American, 31% Hispanic, and 42% white students.

Two years ago I was hired to bring technology to the students who use the school's library media center. Many of the students at North do not have access to computers at home so they are at a disadvantage when they leave North and try to compete with more advantaged students at the universities and in careers.

Two years ago I started planning with district personnel for a 60 computer networked technology lab. I had a 5 year plan to accomplish this goal. During the first year the infrastructure for the network was put in place. This took a lot of patience and money to accomplish. We installed a server with NT software, 15 client computers, a 14 port CD server, and a cable modem for Internet connectivity. During the 1st year the students and staff at North were inservice often to help them learn how to use technology to do research and create finished projects. We always make training sessions hands-on experiences as that is the only way to really learn how to use technology.

At the beginning of this school year, we added an LCD projector and a 32" Destination Gateway computer to the library equipment so training could be seen on large screens. Because of the technology already in place in the library, we received a $15,000 grant from the state to create a class called Generation www. Y. The class was established in Washington state and other states were given the opportunity to try the class and use their curriculum. With the money we purchased 8 more computers, a scanner and a digital camera. The library now has 23 computers for research needs. I teach 2 Generation www. Y classes in the library. The students learn a variety of computer skills i.e. setting up computers, Windows 95, e-mail, the Internet, Power Point, Front Page, collaboration, digital images, etc. The students partners up with a teacher and worked with that teacher to create a technology infused lesson. All of the students showed a tremendous amount of growth in their technology skills and presentation abilities. The teachers enjoyed having students spend time teaching them technology and the teacher's classes enjoyed the technology driven lessons. Next year the students from this class will become technology proctors for different curriculum departments. They will work with all the teachers in that department to infuse technology into their classes. I will teach a new group of students next year who will replace the 1st group when they graduate.

Next school year we will start the year with 12 more computers. That will bring us up to 35 computers. We aren't up to 60 yet, but this is only the end of year 2 in the 5 year plan. All other technology for the plan is in place at this time. The teachers have been inserviced as a whole staff, in curriculum departments, in small groups, and individually. Students are always inserviced on the best sources to meet their specific needs when they use the library as a class. They are also helped individually to find information to meet their learning objectives. Training will never be completed. There will always be newer and better sources to introduce the students and staff to. It is a challenge, but it also makes every day exciting.

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[South Harrison Community Schools] PREV UP

The Secretary's Conference on Educational Technology

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The Secretary's Conference on Educational Technology

Conference Research Materials

1. "Perspectives on Technology and Education Research: Lessons from the Past and Present"

   Margaret Honey and Katherine McMillan Culp, EDC/Center for Children and Technology, EDC/Center for Children and Technology, and Fred Carrigg, Union City New Jersey Board of Education, 1999..
2. "Convergent Analysis: A Method for Extracting the Value from Research Studies on Technology in Education."

   Cathleen Norris and Jennifer Smalka, College of Education, University of North Texas, and Elliot Soloway, University of Michigan, 1999.
3. "Observing Classroom Processes in Project-Based Learning Using Multimedia: A Tool for Evaluators"

   William R. Penuel, Barbara Means, Center for Technology in Learning, SRI International, 1999.
4. "The Technology/Content Dilemma"

   Shelly Goldman, Karen Cole and Christina Syer, Institute for Research on Learning, California, 1999 .
5. "Technology: How Do We Know It Works?"

   Eva L. Baker, National Center for Research on Evaluation, Standards and Student Testing, CRESST, UCLA, California, 1999.
6. "Documenting the Effects of Instructional Technology: A Fly-Ovver of Policy Questions"

   Dale Mann, Professor, Columbia University, and Managing Director, Interactive Inc., New York, 1999.
7. "The Cyberspace Regionalization Project: Simultaneously Bridging the Digital and Racial Divide"

   Jonathan D. Becker J.D., M.Ed., Project Director, Interactive

Inc., 1999.

8. "New Directions for Evaluation of Technology and Student Learning"

   Walter F. Heinecke, Ph.D., Assistant Professor, Department of Leadership, Foundations & Policy, Curry School of Education, University of Virginia, 1999.

9. "Measurement Issues with Instructional and Home Learning Technologies"

   Charol Shhakeshaft, Ph.D., Hofstra University, New York, 1999.

10. "The Idaho Technology Initiative: An Accountability Report to the Idaho Legislature on the effects of monies spent through the Idaho Council for Technology in Learning"

    The State Division of Vocational Education State Department of Education, Bureau of Technology Services, 1999

11. "WEST VIRGINIA STORY: Achievement gains from a statewide comprehensive instructional technology program"

    Dale Mann, Ph.D., Charol Shakeshaft, Ph.D., Jonathan Becker, J.D., Robert Kottkamp, Ph.D., *Afterword by* Lewis C. Solmon

12. "Testing On Computers: A Follow-up Study Comparing Performance On Computer and On Paper"

    Michael Russell, Boston College, 1999

13. "Testing Writing on Computers: An Experiment Comparing Student Performance on Tests Conducted via Computer and via Paper-and-Pencil

    Michael Russell, Boston College, Walt Haney, Boston College, 1997

Perspectives on Technology and Education Research: Lessons from the Past and Present [1]

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This paper offers a perspective that grows out of what we, at EDC's Center for Children and Technology, have learned from nearly three decades of research on educational technology. Rather than providing a detailed account of what we now know about the impact of technology on learning, we discuss where the research field is heading and review what we think of as the most promising directions for technology's role in education (President's Committee of Advisors on Science and Technology, 1997; Bransford, Brown, Cocking, 1999; Coley, Cradler, & Engel, 1997).

Several factors are prompting us to think differently about research. Each one is based in our observations of steady growth and change on other fronts.

- First, there are changes in the nature of the technological elements involved in the research;
- Second, there are changes in the kinds of research questions being asked.
- And third, there are changes in how research is being done and the methods being used.

Technological change. Throughout the 1970s and '80s, technical innovation brought increasingly diverse and more powerful technological tools into schools. Early studies sought to demonstrate the impact of technologies or software on student learning and they were tied very specifically to the particular technologies used by the subjects of the study. These technologies were typically text-based, locally networked or stand-alone computer-assisted instruction applications. As these technologies have become outdated and replaced by graphics-rich and networked environments, the studies that looked at impact on students have been outdated themselves. Additionally, because these studies tended to focus so specifically on particular technologies and their impact, they contributed little to the larger and more challenging project of learning about the generalizable roles that technologies can play in addressing the key challenges of teaching and learning, and about optimal designs for such technologies. The pace of both technological development and the introduction of new technologies into educational settings has dramatically accelerated during the past decade. The combination of computation, connectivity, visual and multimedia capacities, miniaturization, and speed have radically changed the potential for technologies in schooling. These developments are now making it possible for technologies to be designed and deployed to produce powerful and linked technologies that can substantially address some of the core problems of education. For example, there are currently existing technologies that are ideally suited to ameliorating problems like teacher isolation, access to rich and substantial resources, and parent involvement in schooling (Glennan, 1998; Hawkins, 1996; Koschmann, 1996; Pea, Tinker, Linn, Means, Bransford, Roschelle, Hsi, Brophy, & Songer, in press).

- **Changes in the questions being asked**. As the technologies themselves have changed, so have our research questions. We began, in the 1970s, by asking questions about whether certain kinds of computer-based activities improved student learning. Studies did find improvements in student scores on tests closely related to material covered in computer-assisted instructional packages (Kulik & Kulik, 1991). But these studies did nothing to help us understand how technologies might, or might not, help to support the kinds of sustained and substantial inquiry and analysis that we all want our children to achieve. Of course these studies did not help us learn about these more complicated issues because they did not ask the more complicated questions that would be required in order to begin to learn about these issues. More specifically, a key problem with these studies is that they did not acknowledge that effective technology use needs to be embedded in a larger process of school change--that understanding the impact of technology integration requires understanding technology use in a social context--and instead tended to treat technology as a discrete and isolated, yet, it was hoped, overwhelmingly powerful input.

Implicit in these initial strands of research was an assumption that schooling is a "black box" (Tally, 1998). Research attempting to answer the question "Does technology improve student learning?" had to eliminate from consideration everything other than the computer itself and the evidence of student learning. Teacher practices, student experiences, pedagogical contexts, and even what was actually being done with the computers - all of these factors were bracketed out. This was done so that the researcher could make powerful, definitive statements about effects - statements unqualified by all the complicated, gritty details of actual schooling.

The problem was that all the studies conducted in this way - and there were hundreds - told educators clearly that specific kinds of technology applications, such as integrated learning systems, could improve students' scores on tests of discrete information and skills, such as spelling, basic mathematics, geographical place names, and so on. But these studies were not able to tell educators very much that helped them address the larger challenge of using technology to support students in developing capacities to think creatively and critically, and to learn to use their minds well and deeply.

It has become clear through past research on the impact of technology on education that technologies by themselves have little scaleable or sustained impact on learning in schools. In order to be effective, innovative and robust technological resources must be used to support systematic changes in educational environments that take into account simultaneous changes in administrative procedures, curriculum, time and space constraints, school-community relationships, and a range of other logistical and social factors (Chang, Honey, Light, Moeller & Ross, 1997; Fisher, Dwyer, & Yocam, 1996; Hawkins, Spielvogel & Panush, 1996; Means, 1994; Sabelli & Dede, 1998; Sandholtz, Ringstaff & Dwyer, 1997).

While the pressure continues to develop answers about how technologies may contribute to student learning, there has been increasing recognition that technology is a crucial player in a more complex process of change that cannot be accomplished by technological fixes alone. As a result, researchers are increasingly asking questions about how technology is integrated into educational settings; how new electronic resources are interpreted and adapted by their users; how best to match technological capacities with students' learning needs; and how technological change can interact with and support changes in many other parts of the educational process, such as assessment, administration, communication, and curriculum development.

Changes in methods. Answering these kinds of questions also requires the expansion or improvement of a whole range of interconnected resources--including technologies, teachers, and social services--that cannot be isolated for study the way a single software program can be. Further, the kinds of outcomes associated with changing and improving the circumstances of teaching and learning are much more holistic than those measured by most standard assessment practices, and they require more sophisticated strategies of the researcher who is attempting to capture and analyze them. To explore how best to use technology in the service of these goals requires looking at technology use in context, and gaining an understanding of how technology use is mediated by factors such as the organization of the classroom, the pedagogical methods of the teacher, and the socio-cultural setting of the school.

Researchers are now emphasizing questions about the intersections of design, learning, school culture and practices, and other factors that shape the impact technologies can have in schools. A key recommendation growing out of the President's Committee of Advisors on Science and Technology is the need for large-scale, longitudinal studies that examine the consequences of technology use in school settings in concert with a broad range of factors.

To illustrate how technologies can be used to support and extend a broad-based program of education change, we would like to use the example of a comprehensive program of reform that has taken place in the Union City New Jersey schools.

The Union City Story

Union City, New Jersey, is located in Hudson County, directly across the Hudson River from Manhattan. With 60,000 residents in 1.4 square miles, it is the most densely populated city in the United States. The predominant ethnic makeup of Union City is Cuban, though recent arrivals from the Caribbean, Central and South America, as well as long-time Italian residents, add to the diversity of the city's population. Of the 9,803 students in the District's eleven schools, 93% are Latino, 68% of whom do not speak English at home. Thirty two percent of the students are enrolled in the District's bilingual/ESL program. The Brookings Institute classified Union City as one of the 92 most impoverished communities in the United States; 27.5% of all children live below the poverty line and 84% receive free or reduced lunches.

The Center for Children and Technology first began to work with the Union City schools in 1992. We were brought into the district by Bell Atlantic to assist with an initiative known locally as Project Explore. Back in 1992, Project Explore represented an innovative home-school networking initiative. It supplied 135 seventh-grade students and 20 teachers with networked computers at home and at school. While Project Explore has been the focus of our research, our work with Union City extends beyond this effort. In 1995, in collaboration with the Union City Board of Education and Bell Atlantic, we were awarded a grant from the National Science Foundation to conduct a project called *Union City Online: An Architecture for Networking and Reform.* This effort built upon the work of Project Explore, and extended the networking infrastructure to the District's remaining ten schools to help launch a number of other projects to help develop the human infrastructure - the people resources that it takes to make a complex project like this succeed and remain successful overtime. Another core goal of Union City Online was to take a substantial and sustained look at the relationship between networked technology and education reform (Honey, Carrigg Hawkins, 1998).

What is critical in this story is understanding what has happened in Union City during the past 10 years . In 1989, the Union City schools failed in 44 out of the 52 categories that the State of New Jersey uses to determine the effectiveness of their school districts. They were failing in areas such as student attendance, drop-out rates, and scores on standardized tests, and as a result they were facing state takeover. Like many urban districts, Union City was also facing many obstacles to correcting these deficiencies, including language barriers, parents with limited formal education, and students with little incentive to stay in school.

Rather than lose local control of the school district, however, Union City decided to face these challenges head on and drastically reform the entire educational system. The District formulated and implemented a five-year Corrective Action Plan calling for systemic changes in the educational system. Using their own version of a whole-language approach to learning -- which put literacy front and center in their reform efforts -- the District focused on creating a curriculum which would support students in moving away from rote learning and toward the development of thinking, reasoning and collaboration skills. In order to facilitate these goals, the district did a number of things, including the following:

- Classes were extended in most subject areas to 111-minute periods in the elementary and middle schools, and 80-minute periods in the high schools.
- In-service training for teachers was increased from 8 hours a year to 40 hours.
- Buildings were refurbished, windows were replaced, and classrooms and hallways were painted.
- Individual student desks were replaced by cooperative learning tables.
- Textbooks for individual students were replaced with class libraries.

Union City chose to implement the reforms first in the elementary classrooms, then add classes year by year until reform reached every grade level. This decision meant that no student schooled in a reformed learning environment entered a new grade only to face the former method of instruction. Furthermore, the District did not have to face on an unmanageable scale the inevitable headaches that arise during renovations and the first years of new curricula. It also meant the District was able to take the lessons learned from each successive implementation and apply them toward easing the transition in subsequent years.

In addition to curriculum reforms, substantial increases in the District's operating budget played a critical role in Union City's efforts. Over the past eight years, the budget for the Union City School District increased from $37.8 million in 1989 to $100 million in 1997 as a direct result of equitable school funding legislation, known in New Jersey as the Quality Education Act (QEA).

Beginning in 1993, Union City also made a deliberate decision to invest substantially in technology resources. They did this largely out of equity considerations, believing that urban students would once again risk falling drastically behind suburban students if they did not have access to state-of-the-art technological resources. The District built fiber backbones in each of its eleven schools. Approximately 85% of the 2,200 instructional computers -- those in classrooms, media centers, and computer labs -- are part of a district-wide network that connects the schools, two public libraries, city hall, and the local daycare center through T-1 lines back to the central office servers. With a ratio of four students per computer, Union City is now one of the most, if not *the* most, wired urban school district in the United States.

The Center for Children and Technology has been conducting research in relation to both the NSF-funded work in Union City and the Project Explore initiative. Our most recent examination of the impact of the district reforms and the impact of technology on student learning resulted in three important findings:

- The educational reforms have had a substantial impact on students' standardized-test performance, particularly at the K-8 level, where the reforms have been in place the longest.
- The Explore students (those with home as well as school access to technology) gained a substantial "leg up" during the first year of the project, scoring significantly better than their district peers in writing and mathematics. This increase, however, is not due to technology alone, but to increased expectations and to the dedication of teachers and administrators in ensuring that this group of students would excel.
- Writing is the one area where deep and sustained access to technology has made a difference. At the 7th-, 8th-, and 9th-grade levels, Explore students do significantly better than their non-Explore peers on the writing portion of state tests.

Our research suggests that deep and sustained access to technology has the potential to have a positive impact on both students' learning and on the school community's views of their students' capabilities. But our research also suggests that technology in and of itself, in the absence of other components of school reform, would not produce these kinds of changes. We have identified eight key reform strategies integral to the Union City school district's success. These are:

- Instructional leadership at the building level
- Effective school improvement teams
- Extensive professional development in whole-language teaching approaches and cooperative learning
- A strong emphasis on student creativity and the expression of ideas in multiple formats
- An emphasis on providing different points of entry into a task for children working at different ability levels
- A de-emphasis on remediation and an emphasis on learning for all
- Establishment of classroom libraries and media-rich classroom environments
- Multi-text approach to learning that includes the integration of technology into instruction.

Union City has taught us a great deal about how research can focus on improving circumstances of learning, and on determining how technology can help make that happen. This requires viewing technology not a solution in isolation, but as a key component in making it possible for schools to address core educational challenges. A consensus is emerging that the larger issue that needs to be addressed across a wide range of iterative, collaborative research projects is gaining an understanding of the qualities of successful technological innovations as they unfold and begin to have an impact within local, district, regional, and national contexts.

As researchers have come to focus on these issues, a number of common characteristics have emerged in the design and methods involved in this type of research.

Key *assumptions* of this kind of research include:

- Recognizing that technologies in and of themselves rarely bring about substantial change in teaching and learning.
- Understanding that the impact of technology on specific aspects of teaching and learning can be usefully understood only in context. Technologies matter only when harnessed for particular ends within the social contexts of schools. We are not suggesting that this eliminates the need for

careful formative research with users in experimental or laboratory settings. But it does mean that the research agenda is not completed when a robust application has been developed for use in learning settings. It means that a key phase of research must involve looking at how new technological applications can be integrated into school contexts and how they fit into the complex process of school change.

Methodological features of this kind of research include the following:

- It is largely process-oriented. The researchers' goal is to understand *how* innovation occurs in schools, not just what the outcomes correlated with the innovation are.
- It is oriented toward change rather than doing better within the old framework. Tools and programs that are interesting to study are those that support or act as catalysts for change in the *organization* of teaching and learning.
- Teachers and researchers play an active role in interpreting technologies as tools for reforming schools and in supporting and sometimes guiding the change process.
- It is multidisciplinary, combining elements of different fields, including:
    - anthropological lenses on the culture of schools and classrooms and kids' lives inside and outside them
    - developmental and cognitive psychology lenses on learning
    - sociological lenses on school institutions and school change.

There are also important *design* elements that this type of research entails:

- Long-term collaborations with educators. Teachers must be partners and co-constructors of the innovations and of the research process, rather than being viewed as subjects or passive recipients of the innovation.
- Systemic integration and research on the impact of innovations across multiple levels of the school system. Isolated classroom experiments are being replaced by broad examinations of the roles technological innovations can play in the whole system of schooling, at the classroom, individual school, district, state, and national levels. This type of research includes "test-bed" studies that track long-term school changes that are technology-enhanced.

What we have learned so far? Several broadly supported conclusions have emerged from this type of research.

- We have begun to learn about the roles that specific technologies can play in helping to reorganize the education workplace.
- We have become accustomed to defining our strategies and research questions from the point of view of education problems or challenges, rather than beginning from the technologies' capabilities.
- We have come to appreciate the powerful role technology can play in creating new links between schools and the world outside the schools, connecting individuals, providing resources, and broadening the cultural and political contexts available to students and teachers for exploration and examination.
- Most importantly, we have learned that research that is focused on change cannot be done at a distance, nor can it proceed from the assumption that the answers lie outside of the school

community.

Our work in Union City has taught us a great deal about the value of working in collaboration where all parties are learning together and privileging the knowledge, expertise, and limitations that everyone brings to the task at hand.

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Footnotes

1. An earlier version of this paper was prepared for the Intel Corporation by Katherine McMillan Culp, Jan Hawkins, and Margaret Honey.

2. Margaret Honey is Director of EDC's Center for Children and Technology. Katherine McMillan Culp is the Assistant Director for Research at EDC's Center for Chidlren and Technology, Fred Carrigg is the Executive Director of Academic Programs for the Union City New Jersey public schools and has worked in Union City for 27 years.

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UP NEXT [Convergent Analysis: A Method for Extracting the Value from Research Studies on Technology in Education]

Convergent Analysis: A Method for Extracting the Value from Research Studies on Technology in Education

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The costs for implementing technology projects in K-12 classrooms - from the use of word processors in writing classes to visualization software in science classes - are significant. While the price of hardware has plummeted, the companion costs of administrator, teacher, and student time remain stubbornly high. Help is potentially available, however: literally hundreds of research reports on the use of technology in education have been published over the past 30 years. In those research reports are the successes and failures that we can learn from; the reports provide a window on others trials in bringing technology to the classroom.

But frankly, there has been little impact of that research community's findings on the practitioner's community of the classroom. Here are several reasons for this breakdown:

- Research articles are written, by and large, for other researchers; their style of reporting does not address "what can a teacher learn from this study that is applicable to their classroom, today."
- There are many controlled studies that simply report, in a horserace format, who won and who lost, e.g., significantly more students wrote higher quality reports using a word process than those not using a word processor. These studies do not go on to provide an analysis of why - why did that outcome occur?

- Literature review articles tend to follow the model of the controlled studies and similarly summarize the research in terms of who won and who lost, e.g., "these n studies found that there was an impact of word processors on writing quality, while these m studies found no such impact." Or they make the following sort of report: "based on a review of the literature, these n factors are involved in the successful implementation of technology in the classroom." The list is a common-sense list of all the issues involved in making technology a success; again, the underlying "why" is not addressed.
- There are a number of published articles that summarize the literature and attempt to tell the practitioner "what works." However, these articles tend to be at a very high level, e.g., use simulations, use multiple representations, etc. While good advice, these observations are quite general; the conditionality that should temper the application of these pieces of wisdom is typically not provided.

The objective of this short paper, then, is present a method fc extracting value from the research literature that should benefit educational practitioners. We call this method, Convergent Analysis (CA). CA comprises a number of steps.

First, we need to pose a question whose answer can benefit educational practitioners. Thus, rather than going to the literature to ask a broad question such as "does technology lead to increased student achievement," we ask a more focused, practitioner-oriented question:

- *under what conditions do* computers lead to increased student achievement?

That is, what are the issues that need to be addressed, what are the key factors and their values that are involved in leading to a positive learning outcome with technology? For example, from reading the research literature "time-on-task" can be seen as a key factor; for computers to have a positive impact on writing, children need to spend an "adequate" amount of time actually writing on computers. In looking at the range of research papers one can come to an understanding of the different tradeoffs that could result in providing children with "adequate time."

In phrasing the question of computer impact in terms of "conditions under which..." an important opportunity has been created. After identifying those conditions for success the next step is identifying concrete actions that teachers, students, administrators, and parents can take towards realizing those conditions. For example, administrators can work towards getting funds to buy computers so that students can have adequate time writing on the computer. Curriculum coordinators can work towards organizing a curriculum unit to enable teachers to create lesson plans for the unit that enable students to have adequate writing time on computers.

Second, we need to review the empirical studies in the literature and put them into a standardized format. And **third**, we need to look across all the studies in that standardized format, so as to compare and contrast the issues in each study. Clearly, CA is a time-consuming, detail oriented process!

In what follows, then, we highlight the various steps of the CA process and provide examples of the nuggets of wisdom that we have extracted from the literature on writing education and technology using the CA method.

Extracting Value from the Research Literature: A Multi-Step Process

Two major problems confronted us when we started reading research articles about the use of technology in writing education.

1. Comparison across studies was not obvious: The research literature we found was exceedingly diverse in its reporting form and content. How did the issues and findings in one article relate to those in others?
2. Findings were not focused on practitioner issues: The agendas of the researchers carrying out the studies were not necessarily the same as the agendas of the classroom practitioners. For example, we saw researchers structuring their report to highlight one issue: did the technology lead to a positive impact or not. In contrast, a teacher is more interested in the conditions that lead to the outcome, so they could know how to implement and adapt the technology in their classroom.

In what follows, then, we describe how the Convergent Analysis method attempts to address these two problems.

Step 1: Profiles: Standardizing Research Studies

While some fields have de facto standards for research reporting (e.g., studies presented in major psychology or medical journals), the "field" of education and technology is not nearly as organized, and thus the format for reporting an empirical study varies widely. This diversity - a euphemism if ever there was one - makes accumulating the findings across studies exceedingly difficult. The meta-analytic method steers one course through this maze: only studies that admit of specific statistical characteristics are usable in the comparison. Unfortunately, many if not most of the research studies can't meet the stiff meta-analytic demands and are thus excluded from a literature review. But, just because a study isn't tightly quantitative doesn't mean that it is a bad study. We thus wanted to develop a method to analyze the literature that was more inclusive, and viewed the breadth in the research base as a feature, not a bug.

Still further, we observed in reading paper after paper that researchers wrote for fellow researchers. The style of the research reports was clearly academically-oriented, and the content focused on issues of concern to researchers. For example, while a paper might contain an extended discussion of the theoretical framework for the study, it would say precious little about the details of actually running the study in a classroom setting. It is no wonder, then, that the research literature is not consulted by practitioners - researchers don't consider them their audience.

To address both issues we developed a "Research Profile, " a template which now has about 75 categories (e.g., enabling conditions such as teacher experience, technology availability and enactment conditions such as time on task, nature of the task, etc.) The Profile identified the issues that practitioners were concerned with. We consulted with education professionals in order to hone in on the categories of information relevant to classroom teachers as well as school administrators. Over 6 months of reading, rereading, and rerereading the research literature, we went through four major iterations of the profile. And, we still continue to tweak it!

Now, filling out a profile for a research article is no mean feat! It takes hours and multiple readings of the paper in order to accurately fill in the cells of a profile. Interestingly, we reread papers we had originally reviewed before the profile was developed and we oftentimes changed our opinion and our understanding of the research study. The profile helped us focus on the truly salient issues in the research study. In effect, the labeled cells in the profile served as prompts to the reviewer; the profile scaffolded reviewers in getting at all the issues of a study.

Inasmuch as the articles in the literature that we profiled were not directed towards practitioners, it is not surprising that even after multiple readings we were not able to fill in many of the cells in a profile. Researchers did not include in their published articles information that was important for teachers who would want to either replicate a study or adapt the study to the particulars of their classrooms.

Profiling 60 empirical research studies on writing education and technology is a major undertaking. We were fortunate, therefore, to enlist the aid of a graduate class of students at the University of North Texas in the College of Education. Over a 2 month period, 23 students working in teams created the online database of profiles available for public perusal. The findings described in the remainder of this article are based on our readings of these profiles.

Step 2: Convergent Analysis Comparing Across Studies

Once the literature has been put in a standardized format, it is possible to systematically examine the studies to identify patterns. We have called this focusing in, this triangulating process, "convergent analysis" (CA). For example, in looking across all the studies on writing education and technology, we first put those that showed children gaining benefit from using a word processor in one pile, and those that did not show benefit in another. Then, we asked, can we explain why those that did not seem to show benefit on the basis of other findings? In comparing across cells such as task, we saw the following:

- Using a word processor changed the writing task; the first draft was no longer this major stepping stone, since the children modified their documents continuously.

Now, one study that showed no benefit of the technology made that claim on the basis of the "first drafts" of the children not showing much improvement. Using convergent analysis then, we felt we could now explain that negative result. That is, the evaluation used in that study measured the wrong thing; first drafts are not the key marker when children use word processors.

Only by comparing across the literature were we able to ferret out that important observation. And only by having the literature in a standardized format were we able to look across the literature. Thus, we feel the database of profiles provides a valuable resource for educators and researchers who wish to extract value from the research base. To assist in that process, we are now developing computer-based visualization tools that will make it easier yet to compare/contrast across studies.

Practitioner-Oriented Lit Review

To further help focus our review of the literature, we developed a "practitioners'-oriented literature review." That is, in typical literature reviews, authors are still speaking to other reseachers; hence the issues they tend to focus on are not necessarily the issues that would assist teachers or administrators. For example, the quote below taken from one literature review of the writing education and technology field is most illuminating of the problem: the author does not provide suggestions for how teachers who don't have advanced students, who don't have pervasive technology, etc. to get around these problematic -- **and typical** -- situations!

> "Fairly consistently, results favored older, more able students, especially those exposed to relatively lengthy treatments that were well-grounded in appropriate theoretical frameworks."

In our literature review, then, we first posed a set of 13 teacher-oriented questions. See Table 1, below. These questions were suggested to us by practicing teachers. We then searched the online profiles for empirical studies that were relevant to the questions. The resulting "literature review" is available online.

Extracting Nuggets of Wisdom From the Research Literature

In what follows we present two examples of nuggets that we have extracted from the research literature on writing education and technology using our convergent analysis method. A caveat: while one might well want a list of specific pieces of wisdom to serve as prescriptions. If only it were that simple and straightforward! The tension is this: to put forward such a list one must abstract away all the nitty-gritty details of the situation. That process produces very general statements of which Reed's is a shining example: "lengthy treatments" are effective.

Our nuggets of wisdom, then, tend to be more of a process, a way to examine a teacher question and address it based on the literature. This issue will become clearer after we present the two sample nuggets.

Example1: It's All About Tradeoffs

Consider, then, this teacher-oriented practical question:

> "How much time should I spend preparing my students to use a word processor?"

By looking across all the studies at how each study addressed this issue, the "answer" that can be constructed to this question is: "it depends." While on the surface that answer is nor particularly satisfying, providing a description of "what it depends on" may well be useful to teachers:

> It does not seem to be the case that there is some hard and fixed minimum amount of time on the computer that is needed in order to insure a successful writing experience. For example, we did not see that students must have X hours of keyboarding before they start writing. Rather, success in writing on the computer could be had from a broad range of preparedness activities, from computer literacy training (ie., Eastman, 1989, 324; Beichner, 1994, 82) to keyboarding (ie., Kurth, 1997, 190; Dalton & Watson, 1986, 207), from a few hours (ie., Borgh & Dickson, 1992, 141) on the computer to long-term exposure (ie., Diaute, 1986, 325/163; Parr, 1994-95, 135; Snyder, 1994, 148; Beichner, 1994, 82; Fais & Wanderman, 1987, 275). The research does show that in those projects where students tended to have less preparation they had a greater likelihood of obtaining a negative outcome (ie., Lohr, et al., 1996, 307). In contrast, in those projects where students had even a moderate proficiency coming into the writing activity, there was a good likelihood of achieving a positive outcome (ie., McAllister & Louth, 1988, 161; Snyder, 1994, 148; Lehrer, et al., 1994, 80).
>
> In effect, the amount of time preparing students does not seem to be the determining factor for computer-writing success! Moreover, formal keyboard training does not seem to be a necessary ingredient. For example, if the treatment is lengthy then students with less background will catch up through the extended term of the writing experience (ie., Beichner, 1994, 82; Parr, 1994-95, 135). If word processing is available to children after school or at home, then again, they will catch up if the activity is an extended one. If word processing is

used in other subject areas in the curricula, then again, this activity will enable those less prepared to catch up with those more prepared.

In other words, by looking more globally at the research studies, we were able to see how different studies used different strategies to accomplish the same goal. Thus there was no one strategy for achieving the condition that students go into a writing assignment using a word processor with experience using a word processor. The research literature depicts a plethora of strategies. Thus, in any given situation, a teacher will have to decide how to manage the tradeoffs, e.g., extend the writing assignment if your children are less prepared, take advantage of homework periods after school for the less prepared children to become comfortable with word processors, etc., etc., etc.

The fact that there is no simple, straightforward answer to questions such as the above one is not a bug, but a feature! That is, in effect, the literature sanctions teachers to be inventive and to take into consideration the local needs, resources, and even idiosyncrasies of their classroom. From our reading, the research acknowledges the importance and relevance of the local context; prescriptions that ignore that local context implicitly devalue the contributions of classroom teachers towards creating effective learning environments.

Example 2: Technology Changes the Task Which In Turn Changes .... Everything!

Consider, then, another teacher-generated question:

How do I evaluate the quality of the children's writing when they use a word processor?

The literature is most interesting on this point. In writing with pencil-and-paper, children create a first draft, receive feedback, and then revise it. (Time permitting, there may be additional rounds of feedback and revision.) In writing education, one important evaluation measure of a child's work has been the amount of change from the first draft to the final draft.

Now, in studies where children used a word processor, it turned out that when that metric was used, it showed that there was not much change between the first draft and the final draft. On the basis of that finding, the researchers concluded that word processors were not helping children write more effectively. (ie., Owston, et.al, 1992, 164; Owston & Wideman, 1997, 238; Snyder, 1994, 148; Diaute, 1986, 325/163)

Again, a more global perspective on the research literature provides a clearer picture of the situation. Using convergent analysis and looking over all the research studies what we saw was that studies reported that children were constantly modifying their work; in effect, there wasn't a first draft! A word processor does make changing a document relatively simple (e.g., in comparison to changing a penned document or in comparison to changing a typewriter-produced document). The studies observed that the writing process children employed using a word processor was different from the writing process children employed with pencil-and-paper technology. While teacher feedback did cause the children to revise their word-processed documents, they were revising as they wrote, in response to their own thoughts and as a result of conversations with other children who read the documents over their shoulders. (ie, Owston & Wideman, 1997, 238)

This example illustrates how technology changes the nature of what goes on in the classroom: word processing technology engenders a different writing process when compared to the writing process using pencil-and-paper technology. Clearly, that change in process had implications for evaluating the children's written documents.

What other ripple effects does this change in the nature of the activity have on the classroom? For example, "time on task" becomes more problematic, e.g., are there more comfortable intermediate stopping points when using a word processor in comparison to using pencil-and-paper? When should the teacher give feedback to children on their word-processed documents? Again, there are no single answers that are right for all classrooms.

Issues Needing Research & Development

Unfortunately, even a careful reading of the literature will not inform all aspects of classroom practice. Research has not typically been driven by the needs of classroom teachers, and thus there are major lapses and gaps in the research literature.

- For example, there is precious little research on how to support children in transferring their writing skills to other contexts (e.g., from a writing class that uses computers to a social studies test where writing is not done on computers, or even to a social studies class where writing is done on computers!). While there were a few studies that demonstrated that transfer from one writing task to another was achievable, the number of those studies was small and more importantly, there was little discussion on the conditions for achieving that transfer.

In situations such as the above one, there aren't enough studies to which we can apply convergent analysis, and thus we weren't able to tease out the relevant conditions and potential compromises that are needed to inform practice.

What specific topics need to be explored by researchers? For starters, in looking over our practitioners-oriented literature review, we see a number of questions that have only a handful of references back to the literature. If indeed those questions are important to teachers -- and we think they are -- then these questions suggest areas for further exploration (e.g., transfer, collaborative writing, using multimedia for self-expression -- are all topics that have little research behind them).

In addition to more research, new tools to access and analyze the literature are needed.

- Currently, filling out a Profile is a labor-intensive exercise. But, individuals who have actually done profiling, e.g., classroom teachers, report that they came away from reading the literature with a much deeper appreciation and understanding of the research when they used the Profile to organize their reading. Tools to scaffold that profiling activity therefore would be most useful.
- Still further, tools that support teachers quickly doing convergent analysis would also be useful. Any list of questions will be incomplete; specific teachers and administrators will have particular issues that they need input on, and thus they need to be able to quickly and effectively do a convergent analysis of the literature. Currently, doing convergent analysis is definitely "an art;" what tools will support end-users in making this analysis technique routine?

Concluding Remarks

Technology is fast becoming more universal, more pervasive in classrooms. While there are negative arguments and naysayers, the trajectory is clear: as technology continues to pervade our everyday lives, it will do the same for schools and classrooms. The need, the demand for effective ways to use this technology in the classroom will only increase. Research can play an important role in providing educational practitioners with concrete suggestions on why and how to use technology with their students. However, there are real barriers for teachers and administrators in gaining access to the wisdom in that research. Currently, research is written with other researchers as an audience; currently, there are precious few tools for practitioners to use in accessing research; and there are significant gaps in the research since practice has not been a major driver of the research. Towards addressing these challenges and extracting value from the research literature, then, we put forward the Convergent Analysis method.

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Curricular issues

- Why should I introduce and use word processing in my writing activities in elementary school?
- Compared to writing with a pencil and paper, in what ways does the use of a word processor change the children's writing activities? (e.g., do they still make first drafts then final drafts?)
- How should I structure the topics the children write about on the computer?
- What Internet writing activities should I involve my students in and why? How should I use email to encourage writing?
- When might I have my students create multimedia documents and hypermedia documents?
- There are new computer-based tools coming out that support group writing activities; when and how should those be used?

Instructional issues

- How much time should I spend on computer skills before I teach my students to write on the computer?
- How can the technology help with special populations (e.g., pre-emergent writers, dyslexia, disgraphia and learning disabilities)?
- How can I to use collaborative groups in my 4th grade classroom to improve writing?
- How much time should I provide for students to use word processors? (e.g., How many assignments per semester is good? How much time should children to spend at one sitting?)
- How can I prepare children to transfer their writing skills from the computer to paper & pencil?
- How do I prepare my students to move from a Mac word processor, in 2nd grade, to a Windows word processor?

Infrastructural issues

- How can I use a word processor for writing with 1-3 computers in my classroom? How can I use the computer lab, with 15 computers, to compliment my classroom computers?

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[Perspectives on Technology and Education Research: Lessons from the Past and Present] PREV UP

NEXT [Observing Classroom Processes in Project-Based Learning Using Multimedia: A Tool for Evaluators]

Observing Classroom Processes in Project-Based Learning Using Multimedia: A Tool for Evaluators

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Abstract: This paper discusses methods for observing changes in classroom processes in project-based classrooms using multimedia technology. The tool was used as part of a five-year evaluation of a local Technology Innovation Challenge Grant program called Challenge 2000: Multimedia Project. In the paper, we discuss the design of the observation tool and present findings about the differences in classroom processes between Multimedia Project classrooms and comparison classrooms. Project classrooms, we found, are more likely to be learner-centered and engage students in long-term, complex assignments.

INTRODUCTION

Case studies such as from Apple's Classrooms of Tomorrow (Sandholtz, Ringstaff, & Dwyer, 1996) and from reforming schools across the country (Means & Olson, 1995) point to the potential of new technologies to support new ways of teaching. Moreover, these studies have provided rich details about what takes place in classrooms as local technology-supported reforms are implemented.

In addition to these kinds of studies of technology use in schools, in recent years there have been a number of published reports using national data that show the promise of technology to support school reform. Many of these studies rely on survey data, student achievement data, or a combination of both in their analysis. Becker (1999), for example, has published some of the results from his recent survey of teaching practice and technology use in the United States on the World Wide Web, in which he found fewer than 1/3 of teachers were having students conduct research on the Web. The Educational Testing Service has found that when students use computers to apply higher order concepts and when teachers are knowledgeable about how to use computers as productivity tools, students show significant gains in mathematics achievement (Wenglinsky, 1998).

As initiatives and programs that use technology to help drive school reform proliferate, there is an increasing need for tools that can help measure whether these programs achieve anticipated changes in teaching practice. Certainly tools used in both case study research and large-scale studies can be used or adapted for use in evaluation, but researchers must pay careful attention to local program contexts when considering how to use these tools. First, evaluators must first examine the program or initiative's specific design; that is, how interventions are expected to bring about particular changes in teaching practice. The anticipated changes must themselves be described in enough detail for researchers, other observers, and teachers themselves to be able to know when they've achieved those desired changes in teaching practice. Second, evaluators must consider a range of factors related to the opportunities and constraints of the evaluation process itself: What is the scope of the evaluation? Who are the stakeholders and partners in the evaluation? What kinds of data are needed to evaluate the design? How will the data be analyzed? How will different partners in the initiative use the data?

In this paper, we describe how researchers at SRI International's Center for Technology and Learning designed and used an observation tool as part of its evaluation of a local Technology Innovation Challenge Grant. The paper is intended to present both a process and a tool that researchers, program designers, and teacher-researchers might adapt to similar programs and initiatives. First, we describe both the program's theory of action and some of the important opportunities and constraints in the evaluation design. Next, we describe the design of the observation tool itself and how it was used over the course of two years. Finally, we present some of the key findings from the observation study, with specific attention to changes in teaching practice that were observed.

THE CHALLENGE 2000: MULTIMEDIA PROJECT DESIGN

The context of this study is a project funded through the U.S. Department of Education's Technology Innovation Challenge Grants program. The grant was awarded over four years ago to the San Mateo County Office of Education and is jointly coordinated by the county office and Joint Venture: Silicon Valley, a partnership of area businesses focused on improving the quality of life in the Silicon Valley region in northern California. The federal grant funded the Challenge 2000: Multimedia Project and was designed to support Joint Venture's larger education reform initiative, which is aimed at making Silicon Valley students among the most sought-after by employers in the region for jobs in the new workplaces of the twenty-first century.

The Challenge 2000: Multimedia Project aims to engage students in their own learning and develop students' skills of collaboration, decision-making, and complex problem solving. To accomplish these goals, the Project has adopted a model of Project-Based Learning using Multimedia (PBL+MM) and provided supports to teachers in learning how to implement projects and use technology effectively to enhance and support student learning. By implementing student-centered projects and providing supports to teachers, it is expected that classroom processes and teaching practice will change, leading to better outcomes for students.

Student-Centered Projects

The model of project-based learning using multimedia is a research-based model developed by the Challenge 2000 participants in collaboration with researchers from the Institute for Research on Learning. This model incorporates all of the dimensions that have been traditionally associated with a project approach to learning (Blumenfeld, et al., 1991; Kirkpatrick, 1918; Rawcliffe, 1925), such as having a real-world connection, but adds the practice of producing final projects in a multimedia format as a central part of the practice. Among the kinds of multimedia products that students have produced are HyperStudio stacks, Web pages or sites, PowerPoint presentations, animations and videos, and music CDs.

There are seven components of the Project Based Learning Using Multimedia model. Projects are expected to:

- Be anchored in core curriculum; multidisciplinary
- Involve students in sustained effort over time
- Involve student decision-making
- Be collaborative
- Have a clear real-world connection
- Use systematic assessment: both along the way and end product
- Take advantage of multimedia as a communication tool

It is important to note here that the seventh component, use of multimedia technologies, is not conceived as a stand-alone component. Multimedia technologies are intended to be used as tools in the planning, developing, and presenting projects. It is believed that the power of multimedia lies primarily in the extent to which it is integrated within the goals of the project and ongoing curriculum for the class. Products that students create come to serve as public artifacts (Allen & Pea, 1992; Blumenfeld, et al., 1991; Penuel, Cole, Korbak, & Jump, under review) that are part of the classroom community's memory of what it has accomplished.

Teacher Supports for Technology Use

To help teachers implement the PBL+MM model in their classrooms, Multimedia Project staff have created a number of supports and incentives for teachers. The project's theory of action has emphasized the importance of creating a learning community among participating teachers. Initially, the Institute for Research on Learning provided training on how to plan and implement projects in the classroom and on how to use multimedia technology. As the project developed, participating teachers formed a cadre (a Project name) that took on more and more responsibility for planning and conducting their own professional development. As teachers have become more practiced and skilled in implementing the model, they have refined it and shared it with new participants that join the Project.

Multimedia Project teachers establish a peer community of learners in which they gradually take on responsibility for planning and conducting their own professional development. Veteran teachers share their skills with less experienced colleagues. Many of these veteran teachers serve in special roles funded in part through the Multimedia Project. Technology Learning Coordinators in the project are skilled in both the use of technology and innovative teaching practice and are available to teachers in the project for help. Typically, a portion of the Technology Learning Coordinators' time is also spent providing technical assistance to teachers experiencing problems with specific technologies.

The Project also provides a system of recognition and rewards for project teachers. Teachers may apply individually or as partners for mini-grants, allowing them to purchase equipment, software, peripherals, and/or training if they implement multimedia projects in their classes. Providing greater access to hardware, software, and to the Internet has made it possible for students to complete projects they would never have been able to do before the grant. Teachers may also be recognized for their students' contributions to annual Multimedia Fairs held by the school teams participating within the Challenge 2000: Multimedia Project.

Classroom Processes

In the Multimedia Project design, the implementation of student-centered projects and development of a peer learning community with access to technology and technical support are expected to result in changes in what goes on inside project classrooms. Specifically, the design calls for classrooms in which:

- students engage in longer-term, more complex assignments
- teachers act as coaches and facilitators of student learning
- students engage in more small-group collaborative activities
- there is greater involvement with external resources, including heightened attention to external audiences for student work

In turn, these changes in classroom practices are expected to bring about the student outcomes described above-greater skills in collaboration, decision-making, and complex problem solving.

The changes in classroom processes can be seen as intermediate outcomes of the Multimedia Project, benchmarks that can be used to indicate that the project is progressing toward meeting its objectives for student learning. Because of the central importance of changed classroom processes and teaching practice in the program design, we chose to develop an instrument to help measure whether in fact participating classrooms were in fact more student-centered, collaborative, and engaged with external resources. In the next section, we describe the protocol and the evaluation context in which this instrument was designed.

DESIGNING AN OBSERVATION PROTOCOL TO MEASURE CLASSROOM PROCESSES

The Evaluation Context

SRI International (SRI) is under contract to conduct the evaluation of the federal grant coordinated by Joint Venture: Silicon Valley and the San Mateo County Office of Education. The evaluation is a multi-method, five-year study of the implementation and outcomes of the Multimedia Project. As the project has developed over its first four years, the evaluation has moved from a primary focus on documenting implementation (describing student-centered projects and teacher supports) to measuring outcomes of the project. Research questions evolved as the project model has crystallized: each year, evaluators are able to ask more focused questions about teaching and learning in Multimedia Project classrooms.

Throughout the project, SRI International has adopted a partnership approach to the evaluation process. Staff from SRI serve on the Multimedia Project's Coordinating Committee, which meets monthly to discuss the progress of the Project's activities. The Committee consists of representatives from San Mateo County Office of Education, JVSV, the Institute for Research on Learning, and other key program partners. At these meetings, SRI presents information about how teachers and students are participating in and responding to various project activities. Other members of the Coordinating Committee, led by JVSV, identify their own questions that in turn shape each year's evaluation design.

SRI has used case studies, interviews, teacher surveys, classroom observations, school-wide indicators of achievement, and performance assessment data as part of the study. Each of these methods has been used either to document implementation of the project or measure progress toward outcomes.

Year 3 Study Findings

Initially, the observation protocol was adapted from one used by researchers at the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) for use in the studies of Apple Classrooms of Tomorrow in the third year of the program in part to provide evidence to program stakeholders that the Multimedia Project was making progress toward changing classroom processes in project classrooms.

In this first study, 19 classrooms were chosen from among Challenge 2000 classrooms across grade levels for observation in the fall of 1997 and the spring of 1998. Principals from schools where SRI was conducting case studies nominated three technology-using and three non-technology-using classrooms for participation. In most cases, these schools had three teachers participating in the project, or otherwise engaged in technology use, but some did not. In those cases, additional non-technology-using classrooms were observed for the study. The original observation protocol examined variables such as the dominant classroom activities, teacher and student roles, the nature of ongoing student work, and the level of student engagement.

The results of the study showed significant changes in classroom processes from fall to spring, with differences between technology-using and non-technology-using classrooms (Means & Golan, 1998). For example, in the fall students in technology-using classrooms were only slightly more likely than students in comparison classes to be engaged in long-term projects at the time of the observation. By spring, that gap was very wide, with 67% of technology-using classrooms versus 14% of non-technology using classrooms involved in extended projects at the time of observation. Similarly, teachers from both sets of classrooms were equally likely to be engaged primarily in questioning students, a traditional role for teachers, in the fall. In the spring, far fewer technology-using teachers used questioning as their dominant way of relating to students (7% versus 49% for non-technology-using teachers). Instead, technology-using teachers were much more likely to be in a helping or monitoring role within the classroom (43% in the spring versus 18% of non-technology-using classrooms).

Similarly, students in technology-using classrooms were much more likely than their peers in non-technology-using classrooms to be engaged in constructing products and working in small groups in collaborative activity. Again, the differences were much greater in the spring than in the fall. In the fall, 56% of technology-using classrooms involved students in constructing products compared to 39% of non-technology-using classrooms. By the spring, that gap widened: 73% of technology-using classrooms engaged students in constructing products versus 38% of non-technology-using classrooms. While in the fall, few classrooms from either sample engaged students in small-group collaboration, nearly a quarter of technology-using classrooms involved small-group collaborative activity in the spring (compared to 0% of non-technology-using classrooms).

Adaptation of the Protocol for Year 4

A multi-year evaluation affords the opportunity to revise instruments and processes based on what is learned from using them and based on the purposes the instruments serve in the overall evaluation design for that particular year. At the beginning of Year 4, we made some revisions to the observation protocol itself and to the data collection and analysis process.

In Year 4, the evaluation data collection activities focused increasingly on measuring outcomes from the

Multimedia Project. A performance assessment task was created to measure student skills in design, collaboration, and mastery of content. We decided to link the planned replication of the observation study with the performance assessment task. In this way, we could test the design or conceptual framework of the model by answering the question: Do changes in classroom processes lead to different levels of student performance? At the time of writing, performance assessment data are still under analysis. In this paper, we describe the design changes to the observation protocol and report results from Year 4, which continue to point to the promise of the design in changing classroom processes.

Selection of Classrooms

In Year 4, the classrooms were selected using a different method in order to ensure that a large number of veteran teachers would be included in the sample of Multimedia Project classrooms. For this reason, we do not use the terms technology-using and non-technology-using classrooms to characterize the two samples (though the two samples of classrooms can be distinguished in this way). Rather, the study is comprised of 12 project classrooms and 9 comparison classrooms. As in Year 4, observations were conducted once in the fall and in the spring, both times within a three-week window.

Project classrooms selected for the study were a combination of experienced and novice teachers within the Multimedia Project who were funded with mini-grants for the 1998-99 school year. Principals from the project teachers' schools selected comparison classroom teachers. Principals were given instructions to select a teacher in the same grade who was not a part of the project but who taught in a subject area similar to the project teacher. Because the project encouraged partnerships within schools, finding a comparison teacher at the same grade level was not always possible. In two cases, classrooms from the same grade level at a comparable school in the same district were chosen. Still, the resulting classrooms were similar in size and in demographic composition (Table 1).

Table 1.
Composition of Classrooms in the Study

	MM Project Classrooms	**Comparison Classrooms**
Average attendance	27.5 %	28.4 %
Ethnic composition		
White	56 %	61 %
Asian/Pacific Islander	20 %	17 %
Latino	15 %	16 %
African American	2 %	4 %
Other	7 %	2 %

Classrooms did differ on one significant measure, namely the number of computers that were in their classrooms. On average, Multimedia Project classrooms had 6 computers, while comparison classrooms had only 2.

In addition, both samples included only 6th and 7th grade classrooms. We selected classrooms from these two grades because the performance task designed to measure the impact of the project on student learning was targeted to middle grades students.

Addition of Items to Protocol

In Year 4, we added two sets of items to the protocol that have been emphasized by sociocultural researchers (Cazden, 1988; Lemke, 1985; Mehan, 1979; Wells, 19xx; Wertsch, 1991) as important for sustaining extended student inquiry. We asked observers to characterize the different forms of discourse that students and teachers used in the classroom. For example, observers looked for "instructional questions" (Mehan, 1979; see also Heath, 1983) in which teachers ask brief questions of students, to which the answer is already known, to test students knowledge of isolated facts. In general, we were interested to know whether Multimedia Project classrooms engaged in what have been called more *dialogic* (Bakhtin, 1981) forms of discourse than comparison classrooms. By dialogic, we mean forms of discourse that engage students and teachers in discussions that are not always teacher-controlled. By contrast, we anticipated that comparison classrooms might be more likely dominated by a *monologic* or lecture-oriented form of discourse.

We also wanted to be able to analyze better the extent to which teachers allowed students to work independently with limited strategic assistance (Wertsch, 1985). We expected teachers in project classrooms be more inclined than those in comparison classrooms to allocate more time than comparison classrooms to having students practice learning skills on their own, rather than simply demonstrating the skills to students or telling them about what they need to know. We predicted that teachers would provide assistance as needed in project classrooms, but students would be given primary responsibility for their own learning.

Activity as Unit of Analysis

Consistent with a sociocultural approach to observing classroom practice, we also chose to use *activity* rather than observation time as the primary unit of analysis for our Year 4 observations. For purposes of the study, an activity is defined as student engagement in some kind of educationally relevant product. Those products include: a story written, a reading completed, a topic discussed, science observations made and recorded, a set of related problems at the board worked through, a pre-writing activity completed, a painting painted, et cetera. Sometimes an activity produces no tangible product (students listen to a lecture) but the activity is nonetheless organized to produce a definable outcome-e.g. coverage of a particular topic.

Operationally, we defined the activities as different when two or more of the following changes took place in the classroom:

- A new product or *objective* is introduced by the teacher or other students that is followed by new patterns of thinking, communicating, and acting.
- The *topic* changes, whether signaled by movement from one subject area to another or to a different domain within a particular subject.
- The *activity or participant structure* changes; in other words, the way roles are assigned among students or the ways students and teachers are interacting shifts (e.g., from whole group lecture to small group collaboration).
- The *spatial arrangements* in the room shift, in that either people change places or physical objects in the room are re-configured to afford a different kind of activity.
- The teacher (or students) makes a *bid to close* a segment of classroom activity, signaled by specific instructions to students about "wrapping up" or by teachers beginning to review just finished work

or instructing students about re-arranging space in the classroom.

Multiple Levels of Analysis

By selecting activity as the unit of analysis and recording the amount of time spent on each activity, additional avenues for data analysis were opened up. Whereas in Year 3, observers recorded what was happening in three fifteen-minute intervals throughout their observations, in Year 4, observers recorded anywhere from between 1 and 4 different activities across a forty-five minute observation period for each classroom. The Year 4 data permit analysis of the amount of *time* spent in various activities, by the dominant *activities* within classrooms, and by *classroom teacher*. In this paper, we present analyses from the first two dimensions, time and activity.

OBSERVED DIFFERENCES BETWEEN PROJECT AND COMPARISON CLASSROOMS

In this section, we report a number of significant differences we found between Multimedia Project classrooms and comparison classrooms. We consider the extent to which project classrooms were more focused about long-term projects, learner-centered, collaborative, and oriented toward people and communities outside the classroom.

Engagement in Long-Term, Complex Assignments

Time Spent on Long Term Assignments. Students in Multimedia Project classrooms engaged in significantly longer activities ($p<.05$) than students in comparison classrooms. Moreover, they were more likely to be engaged in long-term activities-that is, activities that spanned more than a week of class time-than their counterparts in the comparison classrooms. Moreover, both in the fall and the spring, students spent more time in project classrooms engaged in long-term activities that lasted a week or more (an average of 84% of the time in project classrooms versus 49% of the time in comparison classrooms).

Analysis of the Complexity of Activities. For the Multimedia Project to be successful, it would not be enough to say that students are engaged in long-term activities. Something of the quality of their activity would need to be observed and understood to argue successfully that projects were transforming classroom processes. An analysis of student actions reveals that in fact, students are engaged in complex, cognitively challenging tasks in project classrooms.

Students were observed to be engaged in more of what might be called the *cognitive activities of design.* In other words, they were engaged in the kinds of higher-level cognitive activities characteristic of multimedia design as described by Lehrer (1993): deciding on the structure of a presentation; creating multiple representations, models, and analogies; arguing about or evaluating information; thinking about one's audience; and revising or editing work. Table 2 shows the differences between Multimedia Project and comparison classrooms for those activities marked "dominant" by observers.

Table 2.
Dominant Activities Observed

	MMP Classrooms	Comparison Classrooms

Teacher-directed solo activities (e.g., reading silently, listening to teacher)	13	23
Cognitive activities of design (e.g., deciding on structure of a presentation)	13	3

c2=9.03, df=1, p<.01

Teachers as Coaches and Facilitators

Time Spent in Independent Activity. In Multimedia Project classrooms, more time was spent having students practice skills on their own (whether independently or as a group) with strategic assistance provided by teachers as needed, than having students watch or listen as teachers performed a task for them or explained a process to them (See Figure 2). This difference was particularly pronounced in the spring, when teacher-led activities comprised 29% of time in project classrooms versus comparison classrooms (62%). It is clear from these data that project teachers are more likely to give major responsibility to students for their own learning than do comparison teachers.

Dominant Roles of Teachers. Teachers in Multimedia Project classrooms were much more likely to be engaged in facilitative roles within classroom activities than were teachers from comparison classrooms. In other words, they were more likely to be engaged in assisting or helping students by moving about the classroom and responding to student questions or providing help when they see a need for it. This facilitative role is evident in the greater extent to which teachers help to organize the process by which students can work productively on their own, whether in groups or individually. By contrast, the dominant role of teachers within comparison classrooms was more directive. Teachers were more likely to be explaining concepts, providing information, or questioning students about their understanding of material (see Table 3).

Table 3.
Dominant Teacher Roles Observed

	MMP Classrooms	Comparison Classrooms
Directive Role (e.g., explaining concepts, providing information, questioning students)	11	17
Facilitative Role (e.g., assisting or helping, managing the organization of the task, monitoring as students work on their own)	13	7

$c2=7.81$, $df=1$, $p<.05$

Engagement in Small-Group Collaborative Activity

Time Devoted to Small Group Activity Students in Multimedia Project classrooms were more likely than comparison students to spend time engaged in small group collaboration. This collaboration was supported, moreover, by discourse patterns that allowed students to direct discussion among their peers about the content of the class.

While in the fall, students spent roughly the same amount of time in project and comparison classrooms engaged in small-group discussion, by the spring, project classrooms devoted much more time to this form of discourse. A corollary finding is that by the spring time, only 3% of the time in project classrooms was devoted to "instructional" or known-answer questions compared to 72% of the time in comparison classrooms.

Analysis of Dominant Activities. An analysis by activity yields similar results. There was a more dialogic pattern of discourse within project classrooms than within comparison classrooms in the spring. By dialogic, we mean forms of discourse that engage students and teachers in discussions that are not always teacher-controlled (e.g., lecture). By contrast, comparison classrooms were much more likely to be observed as having a monologic or lecture-oriented discourse dominate classroom time ($c2=7.88$, $df=1$, $p<.01$).

Involvement with External Resources

Time Spent Using the Internet. One of the most valuable tools for connecting classrooms to wider communities is the Internet. By the spring, students in project classrooms spent half of the time observed using the Internet, searching for information, graphics, pictures, sounds, and other material to use for their multimedia presentations. The Internet was not used at all in comparison classrooms, either in the fall or the spring.

Attention to an External Audience. Yet another way that classrooms are connected to broader communities is through the student-led projects themselves, which typically have an audience outside the classroom. In this respect, project classrooms differ significantly from comparison classrooms in the likelihood that students will be engaged in discussion about how their audiences would respond to aspects of a product being produced (Fisher Exact Test, $p<.001$). In spring, 35% of the activities in project classroom involved students considering the audience of their work, whereas none of the activities observed in comparison classrooms found students attending to the audience of their work (beyond the teacher-as-audience).

Discussion and Implications

In each of the dimensions we observed and analyzed, Multimedia Project classrooms distinguished themselves from comparison classrooms by being significantly more student-centered and organized about the collaborative construction of complex products. These findings not only constitute evidence of the projects success in stimulating desired changes at the classroom level at classroom, but also measure power of our instrument to measure and capture these changes.

At the same time, this effect was not evident throughout the whole school year on all dimensions. As in

Year 3, classrooms were much more likely to be engaged in focused efforts to complete student projects in the spring than in the fall, even though care was taken to select only Multimedia Project teachers for the sample. The only dimension in which project teachers differed from comparison classrooms throughout the school year was in the amount of time students spent engaged in small-group collaborative activity.

There are a number of possible reasons why we observed this time-of-year effect. First, one could argue that project teachers are among the most innovative teachers within their schools and were predisposed to become a part of the Multimedia Project. The project, therefore, might not be the cause of the difference in classroom processes. This interpretation is not consistent with case study and interview data, however, in which many project teachers describe how the project has changed their view and practice of teaching.

Another possible interpretation of these data are that even among project teachers, there is a natural building of component skills for projects that takes place in the fall. In the fall, many project teachers use time to teach students research skills or how to use different multimedia software packages. The teachers are still focusing on projects, but their work requires much more direct, teacher-led instruction at this stage.

One third possible reason why we have observed this time-of-year effect is the timing of the Multimedia Fairs. The fairs are held in the spring each year and motivate much of the activity of the project teachers and their students throughout the spring months. At the time of our observations in April, many of the project classrooms were in the middle of working on projects they would show at the fairs. These fairs, in turn, motivate students' attention to an external audience, since people from other schools and the community will see their work.

Even with this school year effect, a convincing case can be made that project teachers are more likely to engage students in small-group collaborative activity, regardless of whether they are working on their multimedia projects. In some cases, it may be that small group work is part of the school's philosophy, and the emphasis on collaboration cannot be attributed solely to the work of the Multimedia Project (see Penuel, Cole, Korbak, & Jump, under review). Still, the success of previous student projects appears to contribute to teachers' eagerness to use collaborative learning as a tool to promote greater mastery of content and skill in working well with others.

Overall, the results suggest that the project is meeting its objective of transforming classroom processes so that they become more student-centered, especially while students are engaged in project-based learning using multimedia. The results suggest a strong role for the projects themselves and for the Multimedia Fair in contributing to these changes, since differences between project and comparison classrooms are much more evident in the spring than in the fall. Indeed, it may be that events like the fairs, which provide concrete links between the classroom and other classrooms and the community, deserve a more important place as levers for changing classroom practice.

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[Convergent Analysis: A Method for Extracting the Value from Research Studies on Technology in Education] PREV UP NEXT [The Technology/Content Dilemma]

The Secretary's Conference on Educational Technology-1999

The Technology/Content Dilemma

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The vision is enticing. Computer technologies become the norm in schools that are equipped with multimedia, graphics and animation, access to Internet and hand-held and remote devices. There is seamlessness of learning activities among home, school and community settings. Students use technologies like they use pencils, books and manipulatives to learn content in all of the subject areas. Learning goes beyond skills and facts, and students develop thinking and problem solving skills. The world is their classroom. In this vision, technologies help students gain mastery of content areas and zip at speeds of the fastest Internet connection well beyond and above the standards. Computer technologies are the norm rather than the exception, and they become enablers rather than another subject to be taught in school.

Where are we in relation to this vision? After two decades of computers in classrooms we can say there have been some major strides. Most schools have computer labs; many schools have computers in every classroom. Over 90% of schools are wired (connected to the Internet), and over one-third of teachers have Internet access in their classrooms, which they and their students use frequently. Most teachers and students use word processing programs. We see teachers who use spreadsheets, simulations, CAD systems and multimedia software, but then again, we are especially tuned into looking and finding exemplars of technology use in schools. We know that a variety of factors predict whether and how teachers will use technology, including access, training, teaching philosophy, and collaboration with other teachers .

Still, broad statistics do not tell the whole story. Are computer technologies transforming classroom teaching and learning? Are they making it possible for students to achieve standards and go beyond? We don't have answers to these questions, yet we can report on some of the trends we see as a result of our work in the field.

IRL has been experimenting for many years with how technologies can leverage learning. In our projects we have spent much time introducing teachers to technology, developing technologies for content integration, and researching the process and practices of the teachers and students along the way. We have worked with a wide range of teachers, some of whom wanted to try computer technologies, and some who felt obligated to try. While we have seen many demonstrations of the content learning we know is possible, we have not seen large-scale adoption of technology in the core subject areas.

Even in schools where there is a strong push to adopt and use technologies, the road to content fulfillment is a long one. We see a pattern where the technology is front and center stage, rather than the academic content. In case after case we see that when computer technologies are adopted, the learning about the technology often takes over, and it is only after several rounds of integrating technology with content that content emerges in strong ways. The technology learning curve tends to eclipse content learning temporarily - both kids and teachers seem to orient to technology until they become comfortable. This dilemma has important implications for teachers' willingness to adopt technology. This is because teachers in core subjects rightly see content, not technology, as the primary focus of their teaching efforts. Teachers' attention to content is important to pedagogy and usually leads to workable solutions.

The good news is that content learning does emerge and is very rich once the technology recedes as the focus of activities in the classroom. At its best, technology can facilitate deep exploration and integration of information, high-level thinking, and profound engagement by allowing students to design, explore, experiment, access information, and model complex phenomena.

Our research also indicates that while infusing technology into schools is worthwhile, it can be a long road from promise to reality.

- *Content integration takes time:* Teachers' first technology projects generate excitement, but often little content learning. Often it takes a few years until teachers can use technology effectively in core subject areas. Initially, teachers and students don't expect much content in technology projects and are satisfied if projects are completed and look good. Teachers learn to use computer technologies and learn how to bring content learning to the forefront with, in some cases, impressive results on the part of the students. Teachers eventually learn to view the learning process in concert with their new technologies and come to understand the ways content interactions can be approached.
- *Glitches galore:* The bumps in the road to technological competence almost guarantee that technology will take center stage over content at first. Inexperienced teachers tend to underestimate the time and complexity of a technology-based project. Software glitches and poor student work habits (e.g. forgetting to save work) can cause huge delays, often meaning that the project has to end just as students are starting to learn some subject matter.
- *Flash over substance:* Students and teachers alike are excited by the presentation capabilities of the new media, resulting in the "flash over substance" phenomenon. Over and over, we see that academic content is allowed to slide initially in a technology-infused project, as students spend their time exploring software capacity for special effects and animation.

Throughout this technology adoption process, teachers tend to worry about content, feel accountable for it, and notice when it is missing. This is a key dilemma in the technology adoption process. Teachers respond to this dilemma in at least three ways:

- *Back off:* Teachers diminish or stop technology use temporarily to make sure students accomplish content. This strategy has worked for teachers, but it usually means that computers, relegated to the sidelines, are employed for supplemental work, special projects, and skills and practice work rather than core subject matter.
- *Keep it simple:* With this strategy, teachers stick to one tried and true technology or use only the technology capabilities with which they are comfortable. With this strategy you might see a teacher encourage writing with word processing, using spreadsheets to make charts and graphs, or encouraging students to create reports using presentation software. The teacher might set goals for learning new software in the summers and plan to incorporate it in one project until a comfort level is reached. While this approach puts a floor on learning (students get some access to technologies), it can also impose a ceiling by limiting exploration and scope.

- *Dive in:* A third strategy is to plunge in head first with students using computer technologies, hoping that teachers and students will learn together about technology. Teachers who use this tend to have a lot of trust in their students' abilities to solve problems and find their way to subject matter. Sometimes this works, but often students and/or content falls through the cracks.

With the right support and access, all of these problems tend to recede as teachers and students gain experience with technology. Teachers learn how much to structure students' access to content. They develop effective assessment tools that help students focus on subject matter. Students come to understand the possibilities and expectations for learning with technology. Teachers and students both learn that different technologies offer different affordances and constraints in relation to what is being learned. They come to know that there are many ways to express subject matter with technology, and that technology won't (and doesn't need to) do the whole job.

To further embellish our characterization of this critical tension between technology learning and content learning, we offer cases from two of our projects. In both cases we have seen teachers handle the technology/content dilemma and move content leaning to the foreground of activities with computer technology.

The "Where's The Math?" Problem

We encountered these issues directly in our Middle-school Mathematics Through Applications Project (MMAP). One of MMAP's accomplishments was that it found a working balance between content learning and engaging with technology that made it possible for many students to achieve middle school math standards. In our description we aim to reveal what occurred between the onset of the content crisis recognition to the achievement of true integration.

The MMAP project created technology-integrated environments where students could participate in mathematics learning through designing solutions to real-world problems. The students role play architects, population biologists, encryption experts, and analysts of geographic databases who are asked to design solutions for various clients. They are equipped with many adult-like computer and mathematical tools. We developed and field-tested four software environments and related design-based curriculum units. Our first software environment was ArchiTech, a mini-CAD system where students could design a floor plan for a structure, manipulate certain variables relating to indoor and outdoor temperature and building insulation values, calculate area, perimeter and heating and building costs, and analyze the data to make design decisions. We designed the program to be a simple and easy to use. It can run on any computer that a school might have. Our hypothesis was that if the software was simple to learn and easy to use, teachers and students would be able to enjoy the environment and concentrate fully on the mathematics and design tasks presented in the units.

We wrote a curriculum unit called *The Antarctica Project* where students design a research station for scientists who are going to work in Antarctica. Before releasing the unit into classroom field tests, we ran through the unit with our staff, as well as a group of 16 local middle school teachers who worked with us over the course of the project, and small groups of middle school students. All learned how to use the program quickly and were engaged in the mathematical work as we had hoped. Even teachers who were skeptical were impressed with the amount and sophistication of the mathematics that they found themselves engaging with as they worked through the design project. They were also impressed with how engaging the software was. Our videotapes and observations of these formative trials were confirming as well. The Antarctica unit was written with a notion that teachers would easily (almost naturally) identify and track when the time was right to introduce new mathematics concepts, activities, skills, or next project steps. Math opportunities would emerge from the designs students created in ArchiTech, which would be a focal point around which mathematical engagements, activities, and conversations would develop. We hoped that the mathematics would be obvious and ubiquitous.

The rough and tumble life of classrooms revealed a different reality. While teachers and students were engaged, on task, excited and involved with the ArchiTech environment and with the design of the research center, it seemed to both teachers and students that they had "fun" with the software and design task, but ignored their mathematics work. The students told us they loved their new math class, because it was fun to use the computers and great to pick up real life architectural skills. When asked if they were learning any math, they looked blankly at us, "No math, but we're learning about the real world." Back with the videotapes at IRL, we found students wrestling with scale and proportion problems related to their research center designs for thirty minutes at a time. They also analyzed the complex relationships among variables in their designs, such as the costs of heating and the insulation values. But the students could not identify the math or depict themselves being mathematical, and the teachers were uncertain about what math was actually accomplished by the students in the groups. By the time we analyzed the tapes and described the math, it was, relative to classroom realities, irrelevant. We asked the question, "Is math really being accomplished if no one in the classroom can see it?" Our answer was "No."

We had a crisis on all levels. The software seemed to be doing its job. It was easy to learn, easy to use, engaging to all of the students and provided many opportunities for mathematical content engagement. On videotape, we could find children working hard during group time yet reporting they did "nothing" mathematically. In project presentations, most students presented lists of rates and costs of specific design variables. When we questioned students we found they were capable of talking in quite detailed ways about the math they had accomplished and used many representations of their ideas in their explanations to us. In general, the students had extremely limited ideas about what constituted mathematics, and we decided the problem wasn't only about technology presence. We realized we had gotten deep engagement with the technology and gloss engagement with mathematics content. The teachers lamented that even though they would sometimes have remarkably complex math conversations with children, they were hard pressed in meetings with parents to say what the children had learned. Imagine the students telling their parents that math class was great because they had fun playing on the computers, and they were learning what it was like to be architects, even though they didn't do any math.

This pattern was repeated in a second classroom. Both teachers were enthusiastic and committed to doing the project the next year. We considered taking a wait-and-see attitude on how the content would play out the second time around. However, being a mathematics project, we felt we should alter the approach to mathematics content to force a balance. A much higher level of productivity for both teachers and students on the mathematics front was needed. We turned our attention to strengthening the unit activities by structuring problems with systems of constraint, and embedding specific unit activities and assessment tools for enhancing mathematics participation. A variety of activities was added that structured students' noticing, naming, further developing and reflecting on the math they encountered in their project design work. We also helped teachers make more productive use of their informal conversations with students. We found that by encouraging teachers to slow down and spend a few minutes with each group, they were able to let students describe their designs, discuss issues or problems, interrogate around relevant math topics, and suggest next steps.

We saw much more balance after consciously marrying the technology environment to the content. Students still engaged with each other, the computer environment and with the mathematics at deep levels. Students still felt they were learning how to use important, adult-like tools, learning about adult work and problem-solving, yet they also knew they were learning about scale and proportion and using and relying on representations of function and variable while making design decisions.

The message: Activity structure is one way to mediate the interplay between engagement with content and immersion in technology environments, so that content is not relegated to the background. Computer technologies, like other technologies, are powerful tools for accessing complex mathematical ideas and concepts. Technologies can be extremely powerful, provided we take the time to embed them in content-rich activities.

The Challenge 2000 Multimedia Project

We have addressed similar issues in our work with teachers in the Challenge 2000 Multimedia Project. This project has a seven-component model for project-based learning using multimedia that has been successful in helping teachers juggle the multiple demands of developing students' subject-matter knowledge while teaching technology and collaboration skills. The model suggests that students engage in multi-media-supported projects that have these seven characteristics:

1. Anchored in core curriculum; multidisciplinary
2. Involves students in sustained effort over time
3. Involves student decision-making
4. Involves students in collaborative work
5. Has a clear real-world connection
6. Incorporates systematic assessment throughout the project
7. Takes advantage of multimedia as a communication tool

The fact that only one of the seven characteristics specifically mentions technology attests to the inseparability of curriculum, pedagogy, and media in the successful use of technology for learning. Successful technology projects need much more than good technology.

In particular, the improved content learning in Challenge 2000 Multimedia classrooms has been supported in at least three ways:

- extensive teacher professional development support
- ongoing assessment of student work - in progress and at project-wide exhibition events
- patience - allowing time for students and teachers to reach proficiency sufficient for high-quality multimedia-based learning

How do these factors interact with teachers as they try to use technology and uphold their responsibilities to help students learn appropriate content and related disciplinary practices (such as historical research)? To find out, we'll look at the experiences of two Challenge 2000 teachers during the 1998-1999 school year.

Views from the field: Two teachers' experiences

Greta Barstow is a middle school history teacher and a teacher/leader in the Challenge 2000 Multimedia

Project. Oscar Jarret teaches a mixed fourth and fifth grade class and is one of the Challenge 2000 project teachers. Both are experienced teachers and technology users who have implemented multimedia projects in their classrooms and have been with the Challenge 2000 Project for several years. With a certain amount of technological mastery, each responded enthusiastically to the idea of improving the content in students' multimedia projects this year. Both decided to do this in part with greatly-increased formative assessment to help focus students on the content in their projects. As Ms. Barstow told her history class, "This is a history class, not a computer class. So I'm going to be looking for evidence that you learned some history in this project."

Ms. Barstow's project was for students to develop a virtual museum on the web that would help visitors learn about Chinese history through Chinese art. Students worked in small groups, with each group focusing its work on one Chinese dynasty. They developed HyperStudio stacks (later ported to the web) with photographs of artwork from the dynasty, related poems and text about history, religion, and culture depicted in the artwork. The stacks also contained photographs of art replicas the students had made themselves.

Ms. Barstow developed a series of handouts titled "Is My Project Good?" This was a question students kept asking her, and she wanted them to learn to answer it on their own. To do this they would critically look at their own work with their teacher, with peers, and alone. The handouts asked students to answer questions such as, "What connections did I make between art and other aspects of Chinese culture?" "Is the information written in my own words, in an interesting way so that my peers will enjoy reading it? If not, what do I need to change/add?" As the versions of "Is My Project Good" evolved, she made the questions more specific and scheduled more opportunities for students to assess by using the forms. For example, with the first form she asked each group to present their in-progress HyperStudio stacks to the class for comment. With the second, she conferenced with each group as they worked to answer the assessment questions together. Formative assessment continued throughout the project. The results were impressive; the content in student projects far surpassed her expectations based on work done earlier in the year, as well as in comparison to projects her students had produced in previous years. She was particularly pleased with the progress made by the class she considered to have the weakest skills.

Still, despite her focus on content and experience in technology, Ms. Barstow experienced many setbacks and frustrations. She experienced:

- *Competition for resources*: Many teachers schedule technology projects for the end of the year, and everyone needed the computer lab at once. Ms. Barstow only got one week of computer time, and for the rest of the project, students had to take turns using the one computer in her classroom.
- *Pressure to cover the curriculum:* As is common for teachers with a large amount of curriculum to "cover", she fell behind as the school year drew to a close. She felt pressure to bring the project to completion and move on, even though many students would have benefited from more time.
- *Insufficient student research skills:* Ms. Barstow was pleased to see students noticing missing content in their projects and begging for library time to find more. Her pleasure turned to disappointment when she saw that her students' research skills were often too low for them to find the information they needed. Although she tried to supplement skills as problems came up, time was too short for her to make much progress.
- *Inefficient technology use:* Students tended to fall into very labor-intensive methods for getting their information into the computer. For example, they entered text in a way that made it almost impossible to edit without completely retyping it. Then, when students decided to revise, they had

to spend precious computer time retyping long blocks of text. It was almost unbelievable how long simple changes could take - a whole class period to reorganize one screen.

In another school, Mr. Jarret was experiencing his own set of triumphs and frustrations as his fourth and fifth graders worked on their Habitat project. They created an on-line guide to habitats they had visited. Earlier in the year, they had made huge dioramas of these habitats with paper mâche animals, plants, and posters that told about the animals, their place in the food pyramid, and their life cycle. Now they photographed their dioramas, did additional research, and created web pages about each animal and habitat. This web-based multimedia project was one of three the class was working on concurrently. There was also a project about artists and another about a class project based on the work of the artist Hokusai.

Mr. Jarret tried to support student learning in three areas: content, collaboration, and use of multimedia. These are the areas judged at the Challenge 2000 Student Interviews and defined in the Challenge 2000 Multimedia Rubric. Mr. Jarret scheduled a series of assessment events during the project to help students come to a consensus on what it meant to have good content and multimedia and to collaborate well. For example, he scheduled two whole-class design reviews. Students used a rubric that they had developed, based on the Challenge 2000 Multimedia Rubric, to critique their classmates' works-in-progress. They asked such questions as, "Is the work organized? How might they make it even more organized?" In this way the class developed a sense of what it meant to have a web page be organized. They spent a lot of time putting themselves in the shoes of imagined web page viewers, and deciding if such a viewer would be able to understand the information and would want to keep looking at the site.

The assessment events were very effective in helping students orient to the audience outside their classroom - once their work was on the web, anyone might see it. Several students gave this as a reason why they did additional research on their projects. Assessment events also helped students see how they could use photographs, drawings, and text together to express what they knew about their habitats and animals. Because of the concurrent work on collaboration skills, students were able to work efficiently and independently away from the teacher. Mr. Jarret gave them a small set of technology tools and procedures for doing the work, and once these were mastered, students used them in a fairly uniform way to get the work done and create the web site. They could concentrate on content and organization without too much attention to technology. They used Adobe PhotoShop to edit and size content elements such as photographs, scanned drawings and maps. They used Claris Homepage to create tables with the content elements they had edited in PhotoShop and descriptive text. Mr. Jarret pointed out particular tools and procedures in each program (e.g. setting the background color in a table cell, setting the text color and size, importing a JPEG picture). Students who became technology helpers used these tools and developed procedures for their work until they could help each student organize his or her page in a short time. Each student became a content expert on his or her animal, and designed and index-card based storyboard to prepare for making the web page. As the deadline of the Multimedia Fair approached, the class became an efficient working group and churned out several pages a day. All in all, the project went smoothly.

Still, there were frustrations related to:

- *Learning the technology:* This was the first time Mr. Jarret had done a web site project, even though he had done many HyperStudio and PowerPoint projects before. He had to learn the technology almost concurrently with his students. Some work had to be redone as the class came upon some unexpected limitations of the methods that Mr. Jarret knew to link pages together. This points to the difference between the level of learning a teacher gets in a training session and the complications of real technology use in a big project.

- *Running out of time:* Mr. Jarret felt that the time spent in assessment and preparatory work was valuable, but it meant that little time remained to get the sites done before the district Multimedia Fair. In the end, a few parent volunteers spent a long night before the Fair checking and linking pages.
- *Keeping it too simple?* Mr. Jarret felt that he had to limit what students put on their web pages to the kinds of media he knew how to use. There was little time for experimentation. Therefore nobody used sound or animation. Pages all were built the same way - as tables. Mr. Jarret felt that this was unavoidable if the project was ever going to get done.

Learning from classroom experience

These classrooms seem like some of the busiest places on earth. A computer crashes and students explode with frustration. A group gets an animation working - everyone crowds around to see. There's a line in front of the scanner. Kids leaf through books looking for just the right picture. The teachers alternate between resetting the printers, looking for more paper, calling the library to see if students can get in, and helping students understand content.

We can see why it is so important for teachers to be able to network with other teachers. So many different problems come up during a project that there is no way a teacher can completely prepare in advance. Teachers need sources of just-in-time advice. Each emergent problem, once solved, becomes a tidbit of knowledge that might just save another teacher a few days of frustration.

The two teachers' stories show that even fairly experienced teachers struggle to balance content integration with available time and resources. Even experienced teachers have to learn new technology, because it is always changing. They also have to find ways to make a technology project teach enough in terms of the subject matter to make it worth the time it takes.

Yet, like the middle school math teachers, both of these teachers can hardly wait for the next year, so they can put to work all the insights and skills they acquired during these projects. Ms. Barstow wants to spend more time conferencing with groups. Mr. Jarret wants to develop templates for students so that they can start their projects at a higher level of technology use. Both were excited about the way their students learned content, and also learned to manage time, collaborate, design, and use new software.

Capitalizing on the Tension of Integrating Technology

The dilemma of learning both computer technology and content exists and will continue to persist. There will always be new computer technologies to learn and there will always be new ways to approach the learning of content. In fact, the problem is a wonderful paradox because technologies have made it possible for many teachers to see that complex ideas and abstractions-the parts of content learning that seem so difficult for students to accomplish-are actually made more accessible through the use of computer technologies. Teachers are seeing that classroom content can be more than assembling pieces of knowledge to be learned, and that technology can offer representations, visualizations, and interactions that really help students negotiate concepts and abstractions. Conceptions of what should be taught and how it can be taught are now in flux, and computer technologies are playing a role in demonstrating how subject area standards can be realistic and accessible for students. Teaching is complicated and computer technologies, like other technologies that came before, create affordances and constraints in the learning process. In both MMAP and the Challenge 2000 Multimedia Project, teachers are working to reconceive their approaches to content as well as their approaches to the media, tools and classroom and virtual activity structures. As always, this process is at the heart of teaching. Teachers from both projects have explained how integrating technology into their classrooms has brought a revitalization to their teaching. They are no longer using the same materials year after year, and they feel that they are getting to learn alongside their students.

The technology learning/content learning dilemma necessitates a call for more complex models and experiences for teacher professional development and more materials that support standards-based learning. Our work at IRL has centered around creating materials and helping teachers create formal and informal opportunities for networks and communities in which to learn technologies and to work on these teaching dilemmas. We advocate for teachers to have time to experiment with technologies, share best and worst practices, study exemplars of student work, and deal with conflicts, successes and disappointments in their attempts with computer technologies. Once teachers have engaged with technology and have seen students engage, shine and go beyond their expectations, they are willing to cope with the tension between attention to technology and attention to content. They need to carve out time and become proficient at being in a classroom that feels like the busiest place on earth while staying focussed on pedagogy. It's a tall order, but we are seeing more and more teachers succeeding.

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[Observing Classroom Processes in Project-Based Learning Using Multimedia: A Tool for Evaluators]

PREV UP NEXT [Technology: How Do We Know It Works?]

Technology: How Do We Know It Works?

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Does educational technology work? Does its application in classrooms help children learn? Can teachers improve their own understanding and practice through technology? Yes! Yes!! And yes!!!

In a period of widespread concern about educational quality, teachers, parents, policymakers, and taxpayers deserve answers that go beyond fervent beliefs and jaunty assertions. They need evidence in order to calm their doubts, justify their expenditures, and strengthen their confidence in what we do. Because we have developed the most sophisticated evaluation methods in the world, we should be able to document strengths and identify shortfalls of technology-based learning systems.

Presented here are a brief set of ideas and guidelines for you to consider, ending with how technology itself can aid in the testing and evaluation process. Let's start with the core notion that evaluation should be planned at the beginning of an innovation rather than tacked on at its end. Evaluation is a planning tool as well as a way to systematically collect and interpret findings and document impact. Scholars (Baker &Alkin, 1973, Scriven, 1967) have divided evaluation into two types: formative evaluation-where information focuses on program improvement; and summative evaluation-where information is used to make a decision among options or to certify the effectiveness of a program. In reality, all evaluation is now both summative and formative: Data help designers and users to improve practice (because nothing works right the first or second time) and also give information about whether the innovation is sufficiently promising to continue investing in. Technical standards for the conduct of evaluation have been produced (AERA, APA, & NCME, *Standards for Educational and Psychological Testing*, 1985). The degree to which evaluations demand many of these concerns depends on where the innovation is going and who has to be convinced. Who are the main consumers of information-the teachers and students in the innovation, its funders, policymakers? Does the evaluation need the blessing of an external evaluator or consultant, to give an arm's length picture of the process, or are you comfortable about building and improving your own systems? Decisions on this score may help you decide whether TO solicit external help or do it yourself. If the former, the guidelines may help you design the kind of request for proposal you want and the kind of standards for work you will accept from a subcontractor. In either case, the ideas below are intended to help you think systematically about what you're doing and how to capture and document accomplishments.

Technology for What?

What is the technology intended to do? Tom Glennan distinguishes between technology-pull and technology-push (Glennan & Melmed, 1996). Goals for classroom technology can focus on learning the use of tools to assist in other areas of learning-for instance, using search engines, e-mail, databases, spreadsheets and word processing to find, analyze, represent, and produce documents and other products to display learning. This type of learning may be related to standards set for the school or the state's children to meet. The focus is on using technology to meet requirements. The requirements pull the technology to them.

A second set of goals may be to use technology power to address new goals that cannot be met in any other way. These could involve the designing of complex simulations, or the collaborative interaction on projects with scientists, other experts, and other students across the nation and the globe. In this case, the technology itself pushes users to new goals and new options.

The object of a third set of goals is to use technology more efficiently to deliver instructional opportunities that match the background and pace of the learners. Such uses typically involve integrated programs where students are helped to acquire specific knowledge and skills.

There are also technologies that focus on the management of classrooms by teachers, but for the moment, let us address the evaluation of students' learning. It is absolutely critical for evaluation to determine the degree of emphasis among the three kinds of goals identified above, to be clear about them, to communicate them to all collaborators, including students, and if revisions occur, to be open about how goals have changed.

Technology Innovations: The How

In every evaluation we have conducted, the road is rocky at the beginning. And whether the evaluation is well funded or operating on a shoestring, hardware and software may not arrive when expected, infrastructure may be delayed or wrong and in need of adjustment, technical assistance may be not fashioned exactly to meet the users' emerging needs. So expect this small amount of chaos.

A good evaluation considers, in addition to goals, who the key participants are-administrators, teachers, parents, students, software providers, consultants-and whose roles are key at what points. Remember also to note how decisions are made to adjust the program, whether they are explicit, and how to keep track of them. This part of evaluation is just good planning.

Implementation of an innovation also depends on a lot of different factors. First, perhaps, is the locus of the ideas for the work. Is it a school-based innovation led by teachers? Is it a collaborative venture involving software that needs to be customized and integrated into a curriculum for particular students or regions? Is it an externally imposed "opportunity" depending upon volunteers or incentives? How systematic is the use of the innovation over what time period? Are we talking about a neat activity that takes a week, or a long-term set of skills (such as modeling and representing data) that can be useful over the long haul and in which it takes a substantial time to develop expertise? Is the project one that emphasizes motivation? The excitement of communication with other students rather than the development of content expertise?

How much documentation about implementation is needed? The schedule and timeline of the beginning and key junctures in the innovation? The integration (or lack thereof) with regular parts of the curriculum? Training requirements and systems for teachers, students, and other participants?

Are the learning topics intended to include the full range of the curriculum? To focus on certain subjects, for instance, history? To concentrate on one or two topics within courses, like earthquakes in an earth sciences course? Is the emphasis interdisciplinary? Is the topic a matter of student choice, and if so, how is activity linked to important expectations?

What is the scope of the project? A few teachers at one school? Teams of teachers at the same grade in a part or all of a district? A statewide scale-up of computer-based curricula? Foundation-supported innovations of different characters and goals at different sites?

Who Benefits?

Which children or students (and teachers) are the key beneficiaries of the innovation? Is there specific background learning or experience that makes children particularly ready for the innovation planned-including language, computer skills or lack thereof, out-of-school experiences, content knowledge? Are the children located at a particular age range or grade level? Are they supposed to be affected over a number of days, weeks, or years? What is a fair comparison group? Others in the school? Children at other schools or sites?

Other Evaluation Considerations

An innovation also has a set of philosophic underpinnings that might need to be considered. Is emphasis placed on exploration and collaboration? On mastery and fluency? On subject matter depth or generalization to a number of topics and subjects? Each of these potential emphases, and many others, of course, may need to be evaluated.

Measures of Outcome and Impact

A few words of advice. Don't hinge the evaluation findings on who likes what. Teachers' descriptions of their "excitement" and students' enthusiasm are certainly desirable, but are probably unlikely to persuade external decision makers of the success of an innovation by itself. If that enthusiasm links to fewer absences, or more attentiveness, then the evaluation will gain power. As an overall dictum, focus first, intensely, and last on student learning. Such a concentration will refer you back to your original goals and may require a redefinition of your original intentions.

Measuring outcomes involves two main components: what you will use to provide the data, and how you will decide whether the findings are sufficiently good to warrant continuation, revision, and so on.

Types of measures include regularly administered tests, either commercial or statewide assessments. There may be special tests already available to measure students' acquisition of the particular area of focus. Often the tests and measures may need to be developed to tap into new uses to which the computer is put. These other measures may include projects, essays, and extended performances, as well as typical tests of knowledge and skills. You need to be sensitive to the fact that if you use open-ended tasks such as performance or essay examinations, you need to use clear criteria to judge performance, and performance should be validly and consistently measured among raters. You should remove, to the extent you can, the bias inherent in having teachers rate their own students or the performance of only students known to be in the technology option. Questionnaires asking about student attitude, ease of use of the applications, and suggestions for improvement from those who participated in the technology may also be helpful.

The most frequent way that evaluators determine whether performance is good enough is by using comparisons. You can compare students in and out of the innovation (although to be certain, you should assign them randomly rather than just using intact classroom groups). You can use pretest versus posttest scores, particularly if you have comparison groups of similar students. If you use pretests and posttests, you'll probably need some external help to deal with the practice effects of the test (learning from the test), interaction effects (how the pretest may enhance the impact of the technology), and the reliability of the measure you use (the difference between pre and post, or a more sophisticated statistical analysis). All this help is readily available. You may also want to follow up students and look at their performance over time, even after they are through with the particular program of interest, in order to determine whether there are long-term effects. When you have sufficient numbers, you should disaggregate your results to see whether the innovation works better for students with certain backgrounds, particular experiences, or specific knowledge.

The major trade-off is whether you link results to the regular test (policymakers would like that) and recognize that it is generally much harder to show impact in this way than on assessments targeted toward the same content and cognitive demands as the innovation. Your local policies may be your best guide here.

Technological Supports for Evaluation

It makes most sense, of course, to use measures that optimize detection of impact for the innovation you are developing. For that reason, we advocate the use of computer-based assessments where possible and where they have sufficient technical quality, including validity and reliability evidence. CRESST has developed measures of problem solving, content understanding, knowledge representation, search strategies, collaboration, and Internet learning, for example, that can be administered by computers. Ideally, you would want to automate information about how students are engaging in their technology use to help you understand why you have obtained given results. Maybe students do best who have a slowly increasing involvement. Maybe there is a threshold that allows them to take off. Maybe their lack of background content knowledge is holding them back.

A second kind of support that CRESST has is a database manager (called the Quality School Portfolio, or QSP) that allows the user to transform databases (for instance, of district or state scores) into a local, longitudinal database for all students. Then students in the technology innovation and those in the comparison group can be sampled on various bases-background, prior subject matter grades, test scores-and the data disaggregated immediately. QSP also allows the use of locally developed outcome and attitudinal measures by providing a resource kit of measures, guidelines for their use, and scanning and analytical capability. In the end, QSP generates a report comparing groups, or a single group at multiple time points. Graphical reporting can be tailored to various audiences for the report.

Summary

To sustain and support the growth of high-quality technology in schools, everyone has to learn to be more aware of what standards of documentation are useful. Each of us can learn to interpret quality information to revise, redesign, or reconceive the ways technology can be used to help our children meet our expectations. Better that we have a hand in it.

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[The Technology/Content Dilemma] PREV UP NEXT [Documenting the Effects of Instructional Technology: A Fly-Over of Policy Questions]

Documenting the Effects of Instructional Technology: A Fly-Over of Policy Questions

by

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PREFACE

[October 22, 1707, The English Channel]

> "Returning home victorious from Gibraltar... [Admiral] Sir Clowdisley...summoned all his navigators... The consensus placed the English fleet safely west of... the Brittany peninsula. But as the sailors continued north, they discovered to their horror that they had misgauged their longitude near the Sicily Isles [which] became unmarked tombstones for two thousand of Sir Clowdisley's troops... [and] four of the five warships."[1]

Appalled by the loss of lives and ships, in the Longitude Act of 1714, the Parliament promised a prize of £20,000 for a better way to navigate than throwing a log overboard and watching it drift off. Without a way to measure time accurately, ships could not determine noon and without a way to determine noon, they could not determine their east-west location. The lack of measurement had serious consequences.

I begin with two assumptions: first, that we want to do credible science and second that we want that science to advance the contribution that instructional technology might make to learning. Trying to advance instructional technology makes my perspective partisan or political in the sense that I am acknowledging a particular value interest in the outcomes of this application of science.

I. EVALUATION RESEARCH ABOUT INSTRUCTIONAL TECHNOLOGY POLICIES

> "640K ought to be enough for anyone." Bill Gates, 1981

Doing research costs money and most evaluation research is paid for by clients---governments or private organizations. Adding a client may complicate evaluation in the same way that adding a patron complicates art: some clients and some patrons have expectations in addition to the outcomes of the otherwise pure event of science or art. The evaluation fish swims in the sea of politics, and should. Anne L. Bryant, executive director of the National School Boards Association says, "School Boards are going to be asking increasingly: 'Demonstrate to us that [computer-based instruction] has results."[2]

Imagine a senior government official on the cell phone, in a cab, running late on her way up Constitution Avenue to a congressional hearing. She knows she will face pointed questions about "All these computers we put in schools". If you answer the call, will you want to help address that skepticism? If you are good at helping, you might add seven figures to the appropriations authorization: if you are really good, you might add eight figures. If you want to help, you have to compel belief and that is likely to be more than good science, it is likely to address pedagogy, politics and economics, all at once.

In my view, evaluation research about education policy is intended to effect decisions and typically addresses pedagogy, politics and economics, all simultaneously.

II: PEDAGOGY

"There is no reason why anyone would want a computer in their home." Ken Olson, President, Chair and Founder of Digital Equipment Corp., 1977

A. *The Efficacy of Instructional Technology.* The overriding question is how powerful is instructional technology? A second order question is, how do we know how powerful that technology is?

First, I believe that instructional technology works.[3] Instructional technology only works for some kids, in some topics and under some conditions but that is true of all pedagogy, all systems for teaching or learning. There is nothing that works for every purpose, for every learner and all the time.

Emphasizing the things that instructional technology has not done has its political uses just as surely as saying that technology works. One continuity among critics of instructional technology is the idea that all teachers are always preferable to all machines, e.g., William L. Rukeyser's statement that, "The best teacher has always been a person, not a machine."[4] The sub-title of the cover story of *The School Administrator* for April 1999 was "A Leading psychologist calls for slowing the rush toward computing". In that piece, the critic of instructional technology, Jane Healy acknowledges that, "...(W)ell implemented simulations and conceptually driven programs may improve learning---if a good teacher is in charge."[5]

But what is known about the learning efficacy of such ubiquitous features of American schooling as the teacher-talk model of instruction? The 770 square foot classroom box? The 180-day (American) school year? We accept and even welcome critical attention to instructional technology that is seldom applied to the implacable regularities of American schooling. That leads to a paradox in which technology from the last generation has been proven inadequate and that from the next generation is unproven. With either negative data or none, the field is left to those who promptly make the next generation of technology the worst enemy of the current generation as in, 'Next year it will be cheaper, faster, smaller or even---more constructivist. So let's wait.'

Our goal should be first, to understand the conditions of pro-social technology use and second to employ that understanding for learning improvement. Both require more penetrating analysis than has heretofore been the standard.

B. *Pedagogy: The Multiple Sources of Learning.*

The first thing to be understood is that there are many, many sources of learning. Technology needs to be disentangled from the other sources. Some are inside and many are outside the school. Parents educate, the family educates, the media educates and so on. Children learn from their teachers, from textbooks, from homework, from the Channel One TV on the wall and they learn from computers.[6]

C. *Pedagogy: Learning Outside the School.* Thus, the contribution of instructional technology is best understood in a context that includes the contribution of all the educators.

Since James S. Coleman's 1966 analysis, it has been generally acknowledged that about 30% of the variation in children's educational achievement comes from their experience in school and 70% comes from other experiences, especially their families, the culture they live in (the media, etc.) and their peers. Coleman's insight works both ways. Families that support learning, advance their children's educational achievement: those that do not or that hinder or disrupt learning, impede their children's educational achievement. In later writing, Coleman called the leverage that families apply to their children's learning, "family capital".

D. Implications for a Research Agenda. There are several implications for an agenda of evaluation research about instructional technology.

1. IT Effects @ Home. We need to account for all the educators---school effects and home effects. How many studies are there of the amount of learning at home that is supported by instructional technology?

2. IT Effects @ School. Inside the school, we need to find ways to measure technology effects separate from teacher or textbook effects. How many studies attempt to measure the amounts of these various phenomena and associate them with outcomes?

3. The Effects of Serious Play. Except for the 'learning-should-hurt' crowd, most educators recall what coaches and early childhood educators have never forgotten---play is a child's work. Entertainment is correctly pilloried as passive and generally purposeless. But active play is strongly connected to learning of all sorts.[7] The fact that we do not know much empirically about what and how children are learning from technology-delivered serious play applications outlines the limits of our imagination.

4. Estimating the Critical Mass of IT. We do not have any very good way to answer school board questions about, How much is too little? Few school boards would accept a coach assertion that 42 minutes a week of basketball practice, in groups of 24, will result in 42 offers of college athletic scholarships. Why then do we allow policy makers to believe that 42 minutes a week of "Computer" from the "The Computer Teacher" in "The Computer Center" will change children's school performance?

5. IT Dosage. Most current evaluations assume that if a school has bought a site license for Electrified Reading: Release 2.0 then the teachers are using it and the children are experiencing (some unknown amount) of it. A generation of so-called "implementation research" suggests the fallacy of that assumption yet we do not have good measures of children's exposure or even of teachers use of programs. We need much more attention to elapsed time, exposure effects, dosage effects.

III. POLITICS

> "The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?" Advice to David Sarnoff in the 1920's.

Politics is the process through which values are authoritatively distributed for a society. Whatever its interpretation in the popular culture, politics has deep implications for the purposes served by government action, for example, which children get what quality of schooling and which not? If measurement is the essence of science, benefit is the essence of public service, analysis may document who benefits from a particular program; politics determines how that benefit will be distributed.

Consider a choice among three public policy options: What would advance the children's interests more:

. Higher pay for already employed teachers?

B. The same amount of money but spent only to hire additional teachers? Or,

C. The same amount of money spent on instructional technology?

Or, assume that the policy goal is to "integrate technology into the classroom". The instant consensus is that can be done only by more professional development for teachers---more in-service, more released time, more contracts to Teacher Centers or, my own favorite, more subsidies for graduate school tuition. We never consider options such as:

. Giving teachers a computer to take home over the summer (and trusting their professionalism, curiosity and commitment)

B. Putting computers into the classroom and letting the kids explore them and co-teach, co-learn with their teachers.

C. Using technology to teach technology---for example, by producing CD-ROM role-playing simulations about what happens in classrooms under different conditions and with different teacher choice-consequence paths.

Neither do we consider making technology so 'transparent' that it does not require training, for example, ATMs. For the most part, policy choices are limited by political power and by the conventional conceptions of education as schooling and of learning as teaching. They all lead to the same labor-intensive conclusions and all are centered on teachers not on learning. We do not, for example ask the following question:

Under what conditions are protein-based teaching systems preferable to digital learning systems?

It is at least possible that digital systems do things that RLHB's

- should not bother to do (keep records)
- do not want to do (drill children)
- can not do (have infinite patience) or
- do not do reliably (treat all children as though they can all learn)?

Or consider "The Learning Odyssey", a complete curriculum for grades 4 though 9, produced by the Agency for Instructional Technology (AIT) that was originally aimed at the home-schooling market. The topics include language arts, math, science, history, art, music, technology and personal development. All subjects are aligned to state content standards. Teacher comments on student work are available by e-mail. Subscription prices are $150/month; $350/3 months; $900/9 months; and, $1,100/year. As part of the price: AIT will pay for a child to be tested with any standardized test required by a local jurisdiction.

AIT describes the "Learning Odyssey" as a replacement for school. "..(L)earning need not be school-based...schools must reinvent themselves as institutions with a far greater purpose, or cease to exist."[8]

Or consider another volatile issue, violence and the Internet. Post-Littleton, the concern to minimize the sources of violence in children's lives is likely also to generate unintended negative consequences. Our understandable attention to the harmful examples of Internet use may cripple wholesome applications of the same technology

We can help children by minimizing violence but also by maximizing good. If we would not ban all pharmaceuticals because some are hallucinogens, then we should also differentiate between pro- and anti-social applications of telecommunications. Except for a few one-off examples of good video games (Tetris, Carmen Sandiego), we have no systematic understanding of the good that can be done through learning related games and the Internet.

In order to encourage more wholesome development of these technologies, we need to understand how they work. To continue the pharmaceutical analogy, we need to identify the active ingredients in these applications followed by clinical trials to document their effects. We need clinical trials that (1) identify and measure the active ingredients of instructional technology and (2) that document the gains associated with amounts of their use.

Whatever the case, analysts, researchers and/or evaluators do not have the right to make deeply political, deeply value choices. Analysts are not elected or authorized by any constituency to make official decisions. Doctorates are not licenses to usurp state legislatures, local boards of education or even superintendents and principals. The role of analysis is to inform decisions, NOT to make them.

IV. ECONOMICS

"I think there is a world market for maybe five computers."
Thomas Watson, Chairman, IBM, 1943

A third of a century ago, James Coleman and Lawrence A. Cremin tried to teach us that we needed a more generous vision of education than one centered exclusively on schools. In addition, we need a more generous vision of progress than that which depends solely on public funds. There are partners who share important and child-centered purposes and they are in the private sector, perhaps especially in technology in the private sector.

A. *Capitol Decisions and Capital Decisions.* Public and private decision-makers are interested in answering the same question: What works? They are because both are making investment decisions. "We need information to show what works and what doesn't. If we had empirical data, policy-makers would be more willing to fund technology and voters would be much more willing to pay."[9]

The interest in 'what works' goes beyond public policy. There is now a category of inquiry called "curriculum due diligence". Because potential investors have a right to know about the integrity of what is being offered, banks and brokers retain curriculum analysts to document those companies in the learning business can actually deliver what they claim to sell---learning. Whether the goal is benefit to the constituents or return on investment, the interest in efficacy is the same.

And in both instances there are competing uses for the same funds. Linda Roberts, the director of the Office of Educational Technology in the US Department of Education said, "School districts will be called to task for 'What are you doing with your money and what difference does it make?"[10] In the public sector, the (implicit) questions are: More highways or more schools? More lights on police cars or more computers in classrooms? More scholarships for college students or more professional development for teachers? The private sector compares buying a magazine to creating software, or starting a chain of day care centers to creating an Internet homework helper site. All of those decisions can be illuminated by data about outcomes for learning.

B. *The Public Benefits of Private Investment.* Where has there been more good for schooling? (A)The clouds of quarter million dollar grants from foundations and State Departments of Education to fund (non-profit) pilot projects and experimental activities or (B) two guys named Jobs and Wozniak trying to breadboard a "home computer" in a Cupertino garage?

We should at least admit that in a capitalist society the engine of innovation---and yes, largely of improvement---is the profit motive. The need for parents to be better connected to their children's learning is widely acknowledged but who has invested more in creating a curriculum of the home? State departments of education or the Lightspan Partnership? (Hint: Creating the 100+ CD ROMs that support reading, language arts and mathematics, grades k through 6 has cost Lightspan $150 million.

C. *The Roles of Government.* Recall that the Internet started out as a Defense Agency Research Projects Administration experiment to connect weapons labs. The Food and Drug Administration supervises clinical trials of privately developed pharmaceuticals on behalf of the public.

V. FOUR INSTRUCTIONAL TECHNOLOGY ADDITIONS TO THE EXISTING CONCEPTION OF SCHOOLING

"Computers in the future may weigh no more than 1.5 tons.""Popular Mechanics", 1949

A.*Adding an Education Focus to Our School Focus.* There are a lot of educators in every society---the TV, newspapers, parents, religious and cultural institutions, video games, sports and the general culture. Every time we hear "education" and automatically think "school" we are diminishing the prospects of improvement.

B. *Adding a Learning Focus to Our Teaching Focus.* The frontal act of instruction, the uncertain business of trying to require children to learn particular things is very difficult (ask any teacher). What if we re-conceptualized "the teaching of children" as "the facilitation of learning"? Likely, it is more possible to arrange learning than it has been to force teaching.

C. *Adding Homes to Schools: adding Parents to Teachers.*Schools and homes remain isolated from each other. And, despite there centrality in the lives of children, we have never had very good bridges between the two. Using Lightspan's Achieve Now! Schools lend children a Sony Playstation (retail cost, $100) as a platform for learning-related video games that are launched by the teacher in the classroom but then completed by children and their parents at home. In a pre/post and experiemental/control evaluation, the children and schools with this home-school-home connection performed better on reading, language arts and mathematics than did those without.

Moving Learning to the Learner. One certain consequence of digital technology is that learning will go to the learner. In the earliest times, boys went with their fathers and uncles to observe the hunt; girls went with the mothers and aunts to discover which plants were edible. The artists of the cave walls moved learning inside. The creation of the common school still required learners to go to the site of learning and to dependent on the knowledge masters. Dependency makes learners vulnerable to the political (and ethnic and class and gender) prejudices of the masters.

Digital communications reverses that commerce (with the Internet, learning goes to the learner) and dramatically transforms that politics. Digital learning can be "The 4 'Anys'---Any Learning, Any Time, Any Place to Any One". The democratizing impacts of that reversal are heartening but only dimly perceived. And the consequences for schools and universities, conceived as physical spaces, have not begun to be imagined although their consequences are probably captured by the observation about technology as a 'train'—you will either be on it or under it.

VI. FOUR EVALUATION RESEARCH QUESTIONS FROM FOUR PERSPECTIVES

"But what is it good for?" Comment on the microchip from IBM Advanced Computing

systems Division, 1968

- From the perspective of science, How certain, how unambiguous, how compelling are the data?
- From the perspective of pedagogy, What implications for practice can be derived from the evaluation?
- From the perspective of *politics,* What political values are served?
- From the perspective of *economics,* What are the cost or financial implications?

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FOOTNOTES

1. Dava Sobel, *Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time,* New York, Walker & Co., 1995, pp 11-13. Sobel continues, "[the night before, the Admiral had been approached by a sailor]...who claimed to have kept his own reckoning of the fleet's location during the whole cloudy passage. Such subversive navigation by an inferior was forbidden in the Royal Navy...[the Admiral] had the man hanged for mutiny on the spot."

2. Pamela Mendel, "Issues That Defined the Year for Schools and Computers", *The New York Times,* Wednesday, December 30, 1998.

3. For some examples, see Charol Shakeshaft's paper also submitted for The Secretary's Conference on Educational Technology and attached herein. For a recent summary of 264 research reviews and reports, see Jay Seven-Kachala and Ellen R. Bialo, 1999 *Research Report on the Effectiveness of Technology in Schools, 6th Edition,* Software & Information Industry Association, Washington, D. C., 1999.

4. William L. Rukeyser, "Computers' Role in Education", the website of "Learning in the real world", Woodland, CA,.

5. Jane M. Healy, "The Mad Dash to Compute", *The School Administrator,* v. 4, n. 56, pp. 6-10. C. F., J.M. Healy, *Failure to Connect: How Computers Affect Our Children's Minds - for Better and Worse,* New York, Simon & Schuster, 1998.

6. Many school people have adopted a constructivist interpretation of the work of children while continuing to focus on teachers as the sole source supply of children's learning. As technology becomes more sophisticated (for example, through artificial intelligence), this singular fealty to the school's employees will be harder to maintain. For example, the experience of the Internet suggests the powerful extent to which technology itself teaches with or without the mediation of adults.

7. C.F., Dale Mann, "Serious Play", *Teacher College Record,* v. 79, n. 3, Spring 1996, pp. 446-469.

8. Michael Sullivan, Executive Director, AIT, "The Heller Report: Internet Strategies for Education Markets", v. 4, n. 2, August 1998, p. 4.

9. Lieutenant Governor Kim Robak, Nebraska, Quoted in Kerry White, "A Matter of Policy," *Education Week,* November 10, 1997, v. XVII, n.11, "Technology Counts: Schools and Reform in the Information Age," p.6.

10. Pamela Mandels, "U.S. Official Calls for Studies of Technology in the Classroom", *New York Times,* April 27, 1998, p. B27.

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[Technology: How Do We Know It Works?] PREV UP NEXT [The Cyberspace Regionalization Project:]

The Cyberspace Regionalization Project:

Simultaneously Bridging the Digital and Racial Divide

I. INTRODUCTION

As this century nears its end, we are a decade into the resegregation of our nation's schools...It has been 45 years since *Brown v. Board of Education* outlawed intentional segregation in the south, but a series of Supreme Court decisions in the 1990's helped push the country away from *Brown*'s celebrated ideals and closer to the old idea of "separate but equal."[1]

As many of the major school districts throughout the country have recently ended or phased out their desegregation plans[2], even some of the most ardent supporters of desegregation have conceded, preferring (in the words of Brown University's Michael Alves) to "make Plessy work"- alluding to the 1896 U.S. Supreme Court decision that allowed "separate but equal" public facilities - by waging a piecemeal attack on educational inequity.[3] Where high-poverty schools are failing, they are given extra money in compensatory funding. Where the curriculum is weak, standards are raised. And if teachers in such schools are underqualified, professional development is enhanced.

Though in totality these individual initiatives are not going to make up for the inequities that are a natural result of resegregation, each is worthy of support irrespective of whether or not you are in favor of "making Plessy work." They are worthy of support because they will help improve traditional educational outcomes such as student achievement. But, what about the non-traditional outcomes? What about the intangible benefits of interracial contact; "those qualities which are incapable of measurement but which make for greatness in a...school"[4] Weren't these intangible benefits of interracial contact the very essence of the *Brown* decision and its precedents?

If we accept, for now, that resegregation is a present reality, and that Caucasian students are going to be in different schools than minority students, is there a way to generate the kind of interracial contact that creates the sort of intangible benefits the Supreme Court believed would emanate from desegregation? Digital telecommunications may be one means to that end. Consider the Cyberspace Regionalization Project.

II. DESCRIPTION OF THE PROJECT

The Cyberspace Regionalization Project uses advanced audio-visual telecommunications to bridge gaps of geography (70 miles) and socioeconomics between two New Jersey high schools, one white and affluent and the other black and low income. Table 1 displays some of those gaps.

TABLE 1.

	ASBURY PARK H.S. (Monmouth County)	HUNTERDON CENTRAL REGIONAL H.S. (Hunterdon County)
ENROLLMENT	757	2005
CAUCASIAN STUDENTS (%)	4	95
STUDENT MOBILITY (%)	35	8
DROPOUT RATE (%)	10	2
POST-SECONDARY STUDY (all types) (%)	65	91
PER-PUPIL EXPENDITURE	\$9,293	\$11,633
HPST PASS RATES (%):		
All areas	41	91
Reading	59	94
Mathematics	76	98
Writing	56	97

Using audio-visual links provided by Intel ProShare software and equipment, students and teachers from the two high schools work together on a variety of curricular and co-curricular activities. Much like corporate executives conducting a video tele-conference, real-time images of the students are displayed on a computer monitor while they work together on various projects such as a science experiment or an electronic literary magazine. Teachers, trained under a grant from AT&T[5] design the interactions and supervise the students throughout the project.

III. THEORY OF THE PROJECT

While the unfortunate consequences of the "digital divide" between races and social classes are often remarked, the Cyberspace Regionalization Project is a unique test of the ability of telecommunications to increase the social purposes served by schools. The major goals of the Project are to:

1. Create an infrastructure of telecommunications to connect two high schools separated by 70 miles
2. Familiarize and train teachers and students at both schools in its use

3. Create programs or activities to bring the students and teachers together
4. Apply those programs to issues of racial understanding, and
5. Apply those programs to improvement and reform in the two schools

These project goals are loosely based on the "Contact Hypothesis" posited as early as 1954 by Gordon Allport[6]. In its most basic form, this hypothesis holds that, under ideal conditions, contact with members of different cultural groups promotes positive, tolerant attitudes. These ideal conditions include:

1. contact involving persons of equal status
2. contact taking place under cooperative conditions
3. contact that is actively supported by powerful authorities

Cyberspace Regionalization appears to meet all of these conditions, since equal status (students) people of different races are working together on a project designed and supervised by teachers and authorized by school district administrators.

IV. MEASURING RACIAL ATTITUDES: The Evaluation Piece

Four decades of empirical research yielded considerable evidence that contact under the conditions described above has beneficial consequences. However, most of that research is now quite dated and often neglected considering the racial attitudes of young people and people of African descent. One of the challenges to evaluating the Cyberspace Regionalization Project lied in developing updated measures of racial attitudes that address salient contemporary issues and that are appropriate for high school-age students.

A. "Old Fashioned Racism." Racial attitude research has prompted a number of theoretical orientations and alternative measures in the past several decades[7]. Racial attitude measures were traditionally comprised of items attempting to assess what has now come to be known as "Old-Fashioned" or "Dominative Racism". An individual with old-fashioned racist attitudes is someone who acts out bigoted beliefs. Prejudice measures that tapped social distance, hostility and derogatory beliefs represent that orientation.

After about 1965, however, standard racial attitude measures had two problems. First, by the middle 1960's, most white people knew the socially desirable answers so that the then standard items were more likely to trigger politically correct responses than valid attitudes. Second, that generation of items did not correlate well with what should have been racially relevant behavior, for example, reported voting intentions or hiring decisions. Replacement items were then developed. The new items that correlated best with racially relevant behavior were those of an abstract, moral tone, or items that used code words or symbols for blacks. These items were thought to tap a new form of racism called "symbolic racism."[8]

B. "Modern Racism." Around 1978, led by John McConahay et. al., symbolic racism was re-named as "modern racism" to emphasize the contemporary nature. The principal tenets of modern racism are as follows.

1. Discrimination is a thing of the past because blacks now have the freedom to compete in the marketplace and to enjoy those things they can afford.
2. Blacks are pushing too hard, too fast and into places where they are not wanted.
3. The tactics and demands of activists are unfair.
4. Therefore, recent gains are undeserved.
5. The prestige granting institutions of society are giving blacks more attention and status than they deserve.
6. Racism is bad.

7. The beliefs of modern racism do not qualify as racist because they are alleged to be empirically grounded.[9]

Thus, those whose beliefs are described as modern racism do not define their own beliefs and attitudes as racist.

C. "Aversive Racism." Around 1986, Gaertner and Dovidio developed the concept of "Aversive Racism". According to this orientation, many white Americans with strong egalitarian values simultaneously have negative feelings and beliefs about blacks. Attitudes need not be consistent and in this case may be the result of conflict between cognition and socialization. Because aversive racists put a high value on egalitarian beliefs, the contradiction between those feelings and racial attitudes is handled by excluding the racist feelings from awareness. Aversive racists also typically avoid close contact with minorities or communicate their underlying negative attitudes in subtle, rationalizable ways. Their negativity is likely to be demonstrated in discomfort, uneasiness, fear, or avoidance of minorities rather than in outward hostility. The subtlety of this "aversive" behavior (in effect, a non-behavior) makes it difficult to document aversive racism through the techniques of behavioral research.[10]

D. The Case for Development of a Multi-factor Racial Attitude Assessment Instrument. Although there has been a considerable investment in studying individual and group racial attitudes using the orientations just described, the differences among the types have yet to be conclusively demonstrated. That recommends an eclectic approach. Additionally, there is a line of research that suggests that racial attitudes are organized around content areas or social issues that change over time. Thus, attitudes ebb and flow with variation in racial interactions and in social and political events.

This is the approach adopted for evaluating the Cyberspace Regionalization Project. By piloting and analyzing scores on a pool of items from various sources, two multidimensional, multi factor measures of racial attitudes were developed.[11] The individual items used came from the following sources:

- The National Opinion Research Center (NORC) at the University of Chicago. All NORC data are based on face-to-face interviewing.
- The Institute for Social Research (ISR) at the University of Michigan. The University's Survey Research Center and the Center for Political Studies are noted for their national election analysis. With minor exceptions, ISR data are also based on face-to-face interviewing.
- The Gallup Organization. Gallup employed face-to-face interviewing over most of its history, but shifted to telephone interviewing in the late 1980's.
- CBS/New York Times public opinion polls.
- Florida State University Professor John Brigham's "Attitude Toward Whites (ATW)" and "Attitude Toward Blacks (ATB)" instruments which were developed for and normed on a college student population.

Some of the survey items tap into similar themes or dimensions as previous research about adult attitudes (c.f., McConahay and Brigham). For example, a number of questions ask students about interracial relationships. Factor analysis allowed us to determine if there was, in fact, an intercorrelation among these items. Factor analysis refers to a family of analytic techniques designed to identify components or dimensions, that underlie the relations among a set of theoretically linked items. Exploratory factor analysis is used to determine which items are meaningfully correlated with the factor presumed to be measured (e.g. interracial relationships). Confirmatory factor analysis is applied to estimate the weights of the individual items on the factors.

Factor analysis of the preliminary data revealed and confirmed the following factors within the two racial attitude assessment instruments. Each factor consists of anywhere from three to seven questions.

Hunterdon Central CRHS SURVEY	ASBURY PARK HS SURVEY
Personal Relations	White Attitude Expectations
Social Justice / Anti-Discrimination	Differences Between the Races
Old-Fashioned Racism	Discrimination
Modern Racism	Personal Relations I (Social Distance)
Social Distance	Personal Relations II (Social Interaction)

One of the benefits of using a multidimensional assessment tool is that we will not have to rely on individual item analysis nor will we have only a single, aggregate racial attitude score. For each student involved in the study, we will have a set of racial attitude factor scores with more room for variation and growth estimation over time than would be the case with individual item analysis.

V. BASELINE RESULTS AND RESEARCH AGENDA

The Cyberspace Regionalization Project Evaluation follows a cohort of students throughout their high school experiences and their increasing exposure to Cyberspace Regionalization. The racial attitude instruments were administered to all of the ninth-grade students in both high schools in the fall of this past school year (1998-99). The ultimate posttest will consist of a re-administration of the instruments to remaining members of the cohort shortly before graduating high school. Exposure to Cyberspace Regionalization and intergroup contact will be monitored and documented throughout the evaluation period.

Baseline results revealed a significant amount of variance in student racial attitudes among and between groups. The pretest data are mostly a point of comparison against the posttest results, but at least one substantive result stood out as particularly interesting. The Hunterdon Central students have less contact with people of African descent than the Asbury Park students have with Caucasian people. Said another way, Hunterdon Central is more racially isolated than Asbury Park. However, despite being more racially isolated, Hunterdon Central students were more comfortable, on average, interacting with students of other races than were Asbury Park students.

VI. CONCLUSIONS

Cyberspace Regionalization engages two of education's persistent problems---equity and school reform. The activities depart dramatically from the standard menu of imposed programs wrapped in supposed solutions. For 40 years, New Jersey has maintained an extensive (and not uncommon) menu of policy initiatives for both racial isolation and school improvement---busing, magnet schools, cadres of special teachers and special curriculum plus a constant strain for reform in school finance. Each has made some difference but not enough. Students remain advantaged or impeded by accidents of birth, economics and geography.

AT&T and other funding partners are bridging these schools with a wider, more powerful world of telecommunications. But how much can telecommunications contribute to central needs for cultural diversity and school reform? If students from the two schools become involved in virtual, but still shared activities, will there be an effect on attitudes about race? Can the intelligent application of computer-related technology in

;chools address the issue of racial and economic disparity between school districts better than court-ordered ousing did?

Answers are likely to lie somewhere between the enthusiasms of technophiles and the cynicism of echnophobes. Technology will not make racism disappear. And, teachers do not believe that computer-related echnology is the (single) answer to the knotty problem of school reform. Keeping in mind the relative slenderness of this (mostly) in-school telecommunications intervention, Cyberspace Regionalization will not be able to change a family's employment circumstances or re-balance the images of commercial television or make store clerks polite and accepting; time spent with Cyberspace Regionalization is a small fraction of a student's life. How significant that fraction is will be addressed through the evaluation. The important questions are not binary ('Yes it does', 'No it doesn't') but rather, how much and how little and under what circumstances.

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1. Orfield, G. & Yun, J.T. (June 1999). *Resegregation in American Schools.* The Civil Rights Project, Harvard University: Cambridge, MA.

2. Among the many major school districts recently ending or phasing out their desegregation plans are Buffalo, NY; Broward County (Ft. Lauderdale), FL; Clark County (Las Vegas), NV; Nashville-Davidson County, TN; Duval County (Jacksonville), FL; Mobile, AL; Minneapolis, MN; Cleveland, OH; San Jose, CA; Seattle, WA; and Wilmington, DE.

3. Kahlenberg, R.D. "Economic School Desegregation." *Education Week.* March 31, 1999.

4. *Brown v. Board of Education*, 347 U.S. 483, (1954).

5. AT&T provided a $500,000 grant for teacher training. Much of the Asbury Park staff was trained by Hunterdon Central faculty. Compaq Computer also provided 175 Pentium II computers for the project. Most of those machines replaced a handful of old 486 and 386 computers at Asbury Park. This narrowing of the "digital divide" between the two schools is not an outcome which should be considered lightly.

6. Allport, G.W. (1954). *The Nature of Prejudice.* Reading, MA: Addison-Wesley.

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[Documenting the Effects of Instructional Technology: A Fly-Over of Policy Questions] PREV UP

New Directions in the Evaluation of the Effectiveness of Educational Technology

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Introduction

At the Secretary's conference on evaluating the effectiveness of educational technology we will be asked to address the following fundamental questions:

How does technology impact student learning?

What can we know about the relationship using data and tools available?

What can we learn about the relationship in the future with new tools and new strategies?

The conference will highlight new and emerging data on effectiveness of technology in primary and secondary education reflected in the latest research and promising practices. The intent of the proceedings is to influence the way educators, teachers, policy makers evaluate and assess the growing investment in technology and to provide schools with tools and strategies for effective evaluation.

In this paper we hope to inform the discussion by discussing recent changes in evaluation theory and practices, and by clarifying some definitions of evaluation, technology and student learning. It is evident that there are multiple definitions of evaluation, of technology and of student learning and theses multiple definitions must be engaged prior to substantive debate over the course of future directions. We will highlight what we believe are instances of promising practices and conclude with a list of recommendations concerning the evaluation of the effectiveness of technology in teaching and learning.

Recent Changes in Evaluation Practices

We should say at the outset that evaluation means many things to many people. According to Glass and Ellett (1980) "evaluation- more than any science- is what people say it is, and people currently are saying it is many different things" (cited in Shadish, Cook and Leviton, 1991, p. 30). In a recent examination of evaluation practice, we are encouraged to bring a critical eye to bear on the purpose and conduct of evaluations. Shadish Cook and Leviton (1991) recommend that in any evaluation endeavor we ask fundamental questions about five key issues:

1. **Social programming**: What are the important problems this program could address? Can the program be improved? Is it worth doing so? If not, what is worth doing?

   To maximize helpful change in the public interest, is it more effective to modify the philosophy or composition of whole programs, or to improve existing programs incrementally-perhaps by modifying regulations and practices, or influencing which local projects are phased out? Should the evaluator identify and work with change agents, or merely produce and explain evaluation results without forming alliances with change agents? Should evaluators try to change present programs or test ideas for future programs? Under what circumstances should the evaluator refuse to evaluate because the relevant problem is not very important or the problem is not likely to ameliorate the problem?

2. **Knowledge use**: How can I make sure my results get used quickly to help this program? Do I want to do so? If not, can my evaluation be useful in other ways?

   Should conceptual or instrumental use have priority? Should the evaluator identify and attend to intended users of evaluations? If so, which users? What increases the likelihood of use, especially for instrumental versus conceptual use?

3. **Valuing**: is this a good program? By which notion of "good"? What justifies the conclusion?

   By whose criteria of merit should we judge a social program? Should prescriptive ethical theories play a significant role in selecting criteria of merit? Should programs be compared to each other or to absolute standards of performance? Should results be synthesized into a single value judgment?

4. **Knowledge construction**: How do I know all this? What counts as a confident answer? What causes that confidence?

   How complex and knowable is the world, especially the social world? What are the consequences of oversimplifying complexity? Does any epistemological or ontological paradigm deserve widespread support? What priority should be given to different kinds of knowledge, and why? What methods should evaluators use, and what are the key parameters that influence that choice?

5. **Evaluation practice**: Given limited skills, time, and resources, and given the seemingly unlimited possibilities, how can I narrow my options to do a feasible evaluation? What is my role-educator, methodological expert, judge of the program- worth? What questions should I ask, and what methods should I use?

   What should the role of the evaluator be? Whose values should be represented in the evaluation? Which questions should the evaluator ask? Given limited time and resources, which methods should be used to best answer the questions? What should the evaluator do to facilitate use? What are the important contingencies in evaluation practice that guide these choices?

Experts on program evaluation (House, 1993; Schorr, 1997; Shadish, Cook and Leviton, 1991) all indicate that program evaluation has undergone a major transformation in the last three decades. It has changed from "monolithic to pluralist conceptions, to multiple methods, multiple measures, multiple criteria, multiple perspectives, multiple audiences, and even multiple interests. Methodologically, evaluation moved from primary emphasis on quantitative methods, in which the standardized achievement test employed in a randomized experimental control group design was mostly highly regarded, to a more permissive atmosphere in which qualitative research methods were acceptable (House 1993. p. 3) The most fundamental shift has been away from a blind faith in the science of evaluation and experimental research methods based on standardized test scores. These changes in the practice of evaluation have significant implications for questions about the future of the evaluation of technology and student learning outcomes.

The primary question to which we always turn to is: How does technology impact student learning? We don't, however, make implementation decisions based on this question. What do we know about this relationship using data and evaluation tools currently available and what could we learn in the future about technology and student learning assuming the application of new evaluation tools and strategies? The answer to the first question is fairly straight forward: The relationship depends on how you define student learning and how you define technology.

If one defines student learning as the retention of basic skills and content information as reflected on norm referenced and criterion referenced standardized tests, then, evidence suggests, there is a positive relationship between certain types of technology and test results. For instance, it is well established that if a teacher uses computer assisted instruction or computer based learning approaches, where the computer is used to manage the "drill and skill" approach to teaching and learning, students will show gains on standardized test scores. This view of technology reduces the equation to only a student, a computer and a test. It ignores the effects of schools, teachers, and family and community life on the learning process. Even tough we cannot control for these variables, we must not discount them.

If, on the other hand, one views the goal of education as the production of students who can engage in critical, higher order, problem-based inquiry, new potential for entirely different uses of technology emerge. For instance, the world wide web can be used as a source of information from which students can draw to solve real world problems by applying technology knowledge and skills. We can evaluate these outcomes but it is more complicated than the standardized testing route. Standardized tests are an efficient means for measuring certain types of learning outcomes but we must again ask ourselves, are these the outcomes we value for the new millennium? To a certain extent we are living out the decisions reflected in previous evaluation methods which constrain our thinking about the purpose and effectiveness of technology in education.

Policymakers, evaluators and practitioners may have vary different answers to fundamental questions about the effectiveness of educational technology. Everyone is asking for results of the investment of technology in education. Perhaps the primary difficulty in coming up with new ways of evaluating or assessing the impact of education technology is that there is little consensus about its purpose (Trotter, 1998). Policy makers often work from a cost-benefit model with increases in norm referenced and criterion referenced test scores viewed as the primary benefits. This appears to be at odds with the view held by teachers or by the public that educational technology benefits include preparing students for jobs, increasing student interest in learning, increasing student access to information and making learning an active experience (all rated above technology's impact on basic skills by parents in a 1998 public opinion survey sponsored by the Milken Exchange).

The question really should not be does educational technology work? "but when does it work and under what conditions?" (Hasselbring cited in Viadera, 1997). In practice, student achievement outcomes are mediated by the processes of teacher integration of technology into instruction. Technology can be used to improve basic skills through automated practice of drill and skill. Technology can also be used to facilitate changes in teacher practices that promote critical, analytic, higher order thinking skills and real-world problem solving abilities by students. The ability of teachers to foster such changes depends significantly on training that shows them how to integrate technology into content specific instructional methods. This has been shown through programs such as the Adventures of Jasper Woodbury conducted at Vanderbuilt University, the national Geographic Society's Kid's network, and work done at University of Massachusetts, MIT and TERC with Simcalc.

Any innovation in our system of education, including technology, raises persistent questions about the purposes of education. Is it to provide training in fundamental and basic skills? Is it to prepare students for the work force? Is it to produce citizens for an effective democracy? Is it to produce an equitable society? Is it to produce broad, life-long learners? Is it to prepare students with critical thinking skills for a complex new world? According to educational researcher Larry Cuban, unless educational policy makers can agree and clarify the goals for using technology, it makes little sense to try and evaluate it.

This raises questions about assessment and evaluation of educational technology. Do traditional, standardized assessments measure the benefits that students receive from educational technology? In the evaluation of social programs in general, the profession of evaluation has moved away from standardized test scores as a meaningful measure of the impact of programs. Evaluation theorists like Mackie and Cronbach have argued that there are too many critical relationships occurring in social phenomenon to be adequately captured by the traditional experimental design. "Social programs are far more complex composites, themselves produced by many factors that interact with one another to produce quite variable outcomes. Determining contingent relations between the program and its outcomes is not as simple as the regulatory theory posits" (House, 1993, p. 135-6). Besides improvements in retention of rote facts, technology can improve student attitudes toward the learning process. perhaps we should be assessing actual, authentic tasks produced through the processes of student interaction and collaboration. Perhaps we should be developing technologically based performance assessments to measure the impact of technology on student learning.

We have been fairly successful in determining the impact of technology on basic information retention and procedural knowledge. However, we have been less than successful in evaluating the impact of educational technology on higher order or metacognitive tinning skills.

Needed: New and Expanded Definitions of Student Learning Outcomes

What are needed more than anything else are a new set of clear learning outcomes for students who must live in a complex world. New learning outcomes must focus on the demands of the new world environment. We need students who can think critically, solve real world problems using technology, take charge of their life-long learning process, work collaboratively and participate as citizens in a democracy. Experts in the area of technology and education such as Jan Hawkins and Henry Becker have provide ideas that could be developed into criteria for new ways of thinking about technology, teaching and learning. These new learning outcomes could be translated into learning benchmarks and new types of assessment and methods for measuring outcomes could developed to measure these benchmarks.

What we are looking for is a transition from isolated skills practice to integrating technologies as tools throughout the disciplines. Jan Hawkins argued that to realize high standards, education needs to move beyond traditional strategies of whole group instruction and passive absorption of facts by students. New more effective methods are based on engaging student in complex and meaningful problem-solving tasks. Technologies need to be used to bring vast information resources into the classrooms. We need a transition from inadequate support and training of teachers to support for all teachers to learn how to use technologies effectively in everyday teaching (Hawkins, 1996).

According to Becker (1992) in an ideal setting, teachers use a variety of computer software, often working collaboratively to address curricular goals. Students exploit intellectual tools for writing, analyzing data, and solving problems and they become more comfortable and confident about using computers (Becker, p. 6). Exemplary teachers use computers in lab settings as well as classroom settings at the school for consequential activities that is where computers are used to accomplish authentic tasks rather tan busywork such as worksheets, homework assignments, quizzes or tests. Means and Olson (1994) outline a set of criteria for successful technology integration projects: An authentic challenging task, a project where all students practice advanced skills, where work takes place in a heterogeneous, collaborative groups, the teacher acts as coach and provides guidance, and where work occurs over extended blocks of time..

Evaluating for New Visions of Technology Teaching and Learning

It is clear that teaching and learning processes are embedded within complex systems. The challenge is to develop evaluation models that reflect this complexity. Just as technology has caused us to reevaluate the nature of knowledge and instruction, it prompts us to reevaluate the forms of evaluation that are brought to bear when examining educational technology. According to Schorr (1997) we need a new approach to the evaluation of complex social programs, one that is theory-based, aiming to investigate the project participant's theory of the program; one that emphasizes shared rather than adversarial interests between evaluators and program participants; one that employs multiple methods designs; and, one that aims to produce knowledge that is both rigorous and relevant to decision-makers. In order to accomplish these tasks it will be necessary to design evaluations of technology in K-12 settings based on the experiences of evaluators, the experiences of program developers, "state of the art" in the field of technology and learning and the various program descriptions.

Several studies and reports have done an exemplary job at pointing us in promising directions for future evaluations of the effectiveness of educational technology. For instance Bodily and Mitchell have prepared an evaluation sourcebook for "Evaluating Challenge Grants for Technology in Education" published by the RAND Corporation. Bodilly and Mitchell (1997) acknowledge that the outcomes sought in technology infusion projects are complex and "not entirely captured by traditional educational measures, seeking better learning outcomes "on a complex variety of dimensions rather than improvements in traditional test scores" but they go on to recommend that some stake holders may be interested in test scores as measures of student learning. They indicate that performance outcomes are the results of complex causes. Technology may be only one of many input variables causing changes. A project's implementation and outcomes are heavily influenced by its context. Goals of various educational technology projects are unique and may not be captured by a uniform evaluation design and multiple evaluation design are required.

In terms of outcome goal, they include a wide variety of possibilities beyond traditional test scores including: short term changes in student outcomes like disciplinary referrals, homework assignments completed or longer term indicators such as changes in test scores or student performances, increased college going rates, increases in job offers to students. Other outcomes are defined as higher order thinking skills, more sophisticated communication skills, research skills, and social skills. More sophisticated outcome measures must be located or developed by evaluators in order to gauge new effects of technology on learning.

Other outcome measures might be found in participants' (teachers and students) perceptions about the implementation, quality and benefits of the program. These might reflect student engagement levels as well as satisfaction levels. Other interim performance indicators might include the effect of the pro0gram on community and family participation or involvement, and student and teacher retention. Declines in disciplinary referrals and special education placements may also serve as outcome measures. The federal government, state departments of education, school district or schools might develop criteria for standards of good practice indicators and associate learning outcome benchmarks.

Other indicators of student outcomes such as higher order thinking skills and ability to apply knowledge in meaningful ways might be measured by performance assessments, portfolios, learning records, and exhibitions. Of course norm referenced and criterion referenced assessments can also supplement these alternatives outcomes. School districts are encouraged to use multiple and varied measures of outcomes. Student performance indicators such as attendance, reductions in drop-out rates, successful transitions to work and post-secondary institutions should be considered. Baseline data should be established at the beginning of the project. They also propose that a list of common indicators across projects be used as a tool for summative program evaluation.

Bodilly and Mitchell refer to work on the evaluation of technology in educational reform conducted by Herman (1995) and Means (1995). They conclude that broad-based technological reforms, those that attempt multiple changes in a school besides the insertion of a single computer-based course, such as an attempt to create a constructivist curriculum across all grade levels supported by computer technology are more difficult to measure in terms of outcomes. They state: efforts to trace the effects of these projects must take into account measuring effects in dynamic situations where many variables cannot be controlled and where interventions and outcomes have not been well defined for measurement" (p. 16). They also assert: "The complex environments in which technology projects are embedded make inference of causal relations between project activities and outcomes tenuous" (p. 20).

Implementation analysis becomes important under these conditions. With all of these complexities, effects of technology on student outcomes may not occur in the short-term evaluations must take into account the different phases of a schools integration of technology: purchasing and installing hardware and software, training teachers, integrating technology into the curriculum and instruction. Evaluation designs must therefore, be longitudinal in design and account for changes in the target population. Tracking comparison groups not exposed to technology or using national surveys to assess the likely level of background effects will often be necessary.

CMC corporation conducted a two year evaluation of the Boulder Valley Internet Project. The project employed a variety of evaluation method and developed a theoretical tool, The Integrated Technology Adoption Diffusion Model, to guide the evaluation. Evaluations should include the contexts within which technological innovations occur. This includes looking at technological factors, individual factors, organizational factors and teaching and learning issues (See Sherry, Lawyer-Brook, and Black, 1997). Evaluation designs must be flexible enough to attend to the varying degrees of adaptation occurring with different content areas. Evaluations must include implementation assessments, formative assessments as well as standard summative and outcomes assessments. Evaluations must include the quality of training programs offering teachers the opportunity to learn new technologies within relevant, subject-specific contexts.

Recommendations

We need to take a more formative approach to the evaluation of technology because of the rate of change in technologies. Technology changes so quickly that teachers are often asked to keep up and integrate new ideas at break neck speeds. The definition of what is the innovation is thus constantly at issue and we must spend time documenting the program which may be changing over time..

In order to get at the complexities of these processes multiple measures (quantitative and qualitative) should be used. These should include traditional experimental and quasi-experimental designs and include such methods as paper surveys, email/web-based surveys, informal and in-depth interviews, focus group interviews, classroom observations and document analysis.

Evaluation design should incorporate longitudinal studies of cohorts of students over several years. In addition evaluation designs should rely less of participants self reported attitudes and more on observations of participants actions within learning contexts. We need to be in classrooms to observe how teachers are incorporating technology into their instruction and what effect this is having on student learning processes. We would recommend further efforts such as those by Milken and Elliot Soloway, to improve the format for research designs to allow for comparisons across sites.

Future evaluations should not focus on simple outcomes measures such as posttests but should also focus on complex metrics describing the learning process such as cognitive modeling (Merrill, 1995). Research and evaluation needs to demonstrate the potential of educational technology but in a way that attends to the layers of complexity that surround the processes. We need to include a wide variety of experts and stakeholders.

Conduct implementation evaluations prior to outcomes evaluations. Spend time necessary to determine whether an innovation as been adopted or fully implemented before trying to determine its effectiveness.

Focus on description of the program, treatment, or technological innovation, develop stronger descriptions of how the technological innovation is configured.

Recognize the complexity of educational technology; Define technology as an innovative process linking teaching and learning outcomes rather than a product which is dropped into the black box of teaching and learning outcomes defined as improvements on standardized test scores. Reduce the reliance on standardized test scores as the primary evaluation outcome. Replace dogmatic applications of experimental designs with designs that allow us to view the complexity of technology based reforms of teaching and learning from multiple perspectives. Adopt multifaceted approaches to evaluation that include case studies and theoretical modeling which includes individual, organizational, technological and teaching/learning aspects of adoption and diffusion of innovations. This means that participant observation of programs will be used as a form of data collection. This type of data collection is not inexpensive but provides evidence beyond self reported data or gross outcome measures like test scores.
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[The Cyberspace Regionalization Project:] PREV UP NEXT [Measurement Issues with Instructional and Home Learning Technologies]

Measurement Issues with Instructional and Home Learning Technologies

I. INTRODUCTION

Evaluating the effects of technology use provokes the same evaluation challenges as does any other program intervention. The issues that I address in this paper are based upon my experience in evaluating the achievement effects of specific technology implementations. The five studies that have offered me the largest learning laboratory are listed in Table 1. Each required a careful description of the technology to be studied, a measure of how much students used the technology, and a measure of achievement gains.

As Mann has pointed out in "Documenting the Effects of Instructional Technology: A Fly-Over of Policy Questions", a variety of stakeholders are beginning to ask questions about technology use in schools. Many of these questions go no further than "Does technology work?" Or, "Does technology use improve student achievement?"; "Is technology in schools worth the money it costs?"; "Are there benefits to students beyond achievement?"

Table 1:

Studies of Technology Use and Student Achievement

Study	Purpose	Sample/ Setting	Method and Data Collection	Findings

The Cyberspace Regionalization Project: "Virtual Desegregation"	Can audio-visual telecommunications be used to bridge gaps of geography, race and social class?	650 9th grade students in two high schools: one upper income with Caucasian students; one lower income with students of African descent.	Four year study. Interviews, surveys, annual pre-post administration of a Racial Attitude Assessment Instrument, administrative data transfer. Four year data collection.	Study in progress. However, baseline data collected in the Fall of 1998 reveal gaps in interracial contact and significant variation in racial attitude scales.
Lightspan Achieve Now and the Home-School Connection: Adams 50, Westminster, CO.	Does implementation of a game-like, CD-ROM-based, K-6 curriculum launched at school and used at home with families improve student achievement in math and language arts?	6 elementary schools; 2,000+ students and 55 teachers in grades 2-5.	Three year study of 3 elementary schools using Lightspan compared with 3 not using Lightspan. Annual pre-post Terra Nova data, district reading test scores, Colorado test scores. Observations in classrooms. Interviews with parents, teachers, and students four times each year. Learning Combination Inventory. On-line data collection.	After one-year of implementation, the students in 3 treatment schools surpassed students in the control schools and significantly outperformed them on the CTB-Terra Nova (Reading and Math).

Read 180 Scholastic, Inc. (National, urban settings)	Can a CD Rom interactive basic skills curriculum remediate prior deficiencies for early adolescents who are 4 or more grades behind in achievement?	Random assignment of 1,400 6th and 7th grade students to Read 180 and control classrooms in 7 big city school districts (Chicago, Dallas, Miami- Dade, Houston, Atlanta, San Francisco, and Boston)	Two year pre-post measures in Stanford 9 Language Arts subtests in Read 180 and control classrooms. Self efficacy, discipline, achievement in other subject areas, and attitude toward school are examined.	Data collection begins September 1999.
Technology Impact Study in the Schools of the Mohawk Region, New York State	What is the impact on student achievement associated with a $14.1 million investment in educational technology?	55 school districts, 4,041 teachers, 1,722 students, 159 principals, 41 superintendents	Teacher survey, principal survey, administrative data transfer of New York State PEP and Regents test scores	For the schools that had the most technology and training for teachers, the average increase in the percentage of students who to ok and passed the Math Regents Exam was 7.5; the average increase for the English Regents Exam was 8.8.
West Virginia's Basic Skills/Computer Education (BS/CE) Program	What effect does a $70 million statewide comprehensive instructional technology program have on student achievement?	18 elementary schools, 950 fifth grade students, teachers and principals in all the schools	Teachers survey Principal survey Student survey Observations Interviews with principals, teachers, and students Stanford 9 data for two years	A BS/CE technology regression model accounts for 11% of the total variance and 33% of the within school variance in the one-year basic skills achievement gain scores.

II. WHAT ARE WE MEASURING?

Many of the program administrators responsible for IT have not thought through the questions they want answered by documentation research, nor can they be expected to since operational responsibilities often preempt evaluation. Part of the job of the evaluator is crafting work that serves the needs of the stakeholders: Is this an evaluation for re-funding? For use in curriculum refinement? For analysis of classroom instruction? For public relations? For all of these?

Because stakeholder needs are not always clear, the first measurement challenge is to determine the technology "input" to be examined. Technology is lots of things: computers, CD-ROM and videodisc players, networked applications. If we focus on computers, it generally is not the use of the computer per se that is of interest, but rather a specific use, especially particular software.

For most readers of this paper, the "what is the technology" question will seem elementary. However, my experience has been that many stakeholders -- particularly school administrators, school board members, and legislators -- expect that if hardware is purchased, then improved achievement should follow. A common situation we have faced is being asked to determine achievement gains in schools where computers and word processing software are purchased. The notion that doing anything on a computer should lead to (any) achievement gains is widespread. *(We were once asked to measure the math achievement impact of having provided Corel's WordPerfect word-processing software to all the elementary teachers of a district!)* Therefore, identifying what technology use is being analyzed is a first step, and a step I would not bother to relate had I not learned the hard way that identifying the technology to be measured requires a considerable amount of interaction with stakeholders.

Is the technology question really a focus on the teaching efficacy of a particular software that students are using? If so, is there a relationship between the software design characteristics and student achievement? Do any of the following make a difference: instructional control, feedback, objectives and advance organizers, cognitive strategies, conceptual change strategies, scaffolding of learning support, still and animated graphics, dynamic visualization, video, navigational technique, text and story content, game context and visual metaphor fantasy context, Window presentation styles?

Or, is the question about multiple sites for technology use? The home? The school? Both? And if so, how much of what interaction in which site is related to achievement?

Do different technologies result in different kinds of achievement? For instance, do telecommunication distance learning technologies such as access to online resources, document exchange and discussion, or professional development on-line improve student achievement? If they do, is this be a direct relationship? How would we isolate these uses while examining student achievement?

It is easy to see how an initially simple question like, "What is the relationship between technology use and student achievement?" blossoms into refinements and further definitions. Carefully defining the technology to be studied then takes us to the next step.

III. MEASURING USE OR EXPOSURE

Just because technology is present does not mean that the students are using it. How do we measure the intensivity of student use?

We faced this question in every study we have done. We have used observations, file server records, student reports, parent reports (thousands of telephone interviews, each logged and coded), teacher reports, and on-site observations. Because it isn't feasible to shadow every student every day, observational data, although probably both reliable and valid, is not often feasible. Metering and file server records, although able to record time on the computer or software, are not available in most schools. The next level of data is self report data from students, which can be verified by teachers and parents. If we are examining the relationships between the use of some technology and student achievement, we do sampled surveys of use. We ask students, teachers, and parents about the previous day or week's activity. We use e-mail, web-site, telephone, face-to-face, and paper and pencil surveys to document student use.

Not surprisingly, filling out surveys is not a priority for many educators, whether they are sent by e-mail, snail mail, or over telephone lines, but we have always had excellent cooperation that easily exceeds the minimum standards for sample size and response. Student reports of their own behavior tend to be more accurate than parent or teacher responses, although children younger than fifth grade often have difficulty estimating time. Teachers are usually able to tell us how much in-class time that students spend on the computer, although it often depends on which day, which class, and which student. Teacher reports are aggregate reports, while student reports are specific to the individual student.

Because student use (at least in schools) is related to teacher use of and comfort with technology, we include in the description of the technology the amount of teacher professional development and integration into the curriculum. We ask teachers and administrators about use. We examine teacher professional development participation, both in school and out of school, formal and informal. Self reports of technology literacy, faculty meeting agendas, lesson plans, and observations all help to describe what the teacher knows about technology, how comfortable the teacher is with technology, and how and how often the teacher is able to integrate technology into the curriculum.

IV. HOW DO WE KNOW IF TECHNOLOGY WORKS? MEASURING THE DEPENDENT VARIABLE(S)

While this paper is about measurement issues and student achievement, there are worthy reasons to use technology beyond bottom-line achievement. We have examined technology use and self efficacy, attitude about school, attendance, and discipline.

However, to understand the relationship between technology use and student achievement, we are most comfortable with examining gains in individual student achievement that would be reasonably expected because of the technology. Thus, we don't expect that time using music composition software would accelerate student learning in biology. The measures used must relate to the expectations of the technology.

We use the same data that schools use to determine achievement, even when we might not think it is the best form of measurement. We use these data because that is how the districts and their superordinate jurisdictions measure achievement. While we can argue that most achievement tests do not accurately or fully explain what students learn, the reality is that achievement data is often the best we have.

Thus, we often rely upon gain scores from September to May on norm referenced tests such as the Stanford 9, the Iowa Tests of Basic Skills, or CTB-Terra Nova. Since most districts don't test twice a year, this usually requires some negotiation. However, the result is that we have individual student gain scores to relate to the individual student use measures.

Additionally, we use grade, teacher developed tests, state achievement tests, district achievement tests, and authentic displays of student work. The more types of data, the better the understanding.

V. CONCLUSION

If you look across the measurement literature (and Jay Sivin-Kachalan and Ellen Bialo have, see sources below), you will find different methods to study different combinations of different interventions. It is hard to make those disparate studies add up in a way that compels belief. In part, that is the nature of decentralized science in a democracy. Still, we would like to see a short list of preferred evaluation methods or models, each for example, with two alternative methods for different intervention niches like early childhood literacy or gender studies of literacy applications delivered on the Internet. We would like to see those models developed and recommended (or even encouraged) by funding agencies. That way, at least some of what we do would add up in a more direct fashion than has so far been the case.

Measuring technology outcomes is undeniably messy and imperfect. It is also important for the practice-improving signals that can be developed even from this sometimes frustrating enterprise. It may also be helpful to recognize that just as instructional technology continues to evolve and to improve, so does our ability to document inputs and measure effects.

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APPENDIX

Ten Practical FAQ's (Frequently Asked Questions) about measuring IT effects

1. **Q**: It is too early to expect results. **A**: It is always too early but if there is a partial implementation (which is almost always the case anyway) then we need sensitive measures and an expectation of probably faint signals of effect.
2. **Q**: Instructional Technology wasn't the only thing we did. We changed textbooks, moved to a house plan, etc. **A**: Good, there are no single answers, not even technology. If the documentation plan calls for measuring the different dimensions of all the things that were going on, then regression analysis will allow testing for differences in the strength of relationships between different input clusters and outcome measures.
3. **Q**: We changed tests two years ago. Can we still look for effects? **A**: Everybody changes tests and that is more of an inconvenience to the analyst than a barrier to inquiry. The whole point of nationally normed tests is to facilitate comparison.
4. **Q**: We keep changing and replacing both hardware and software. How can we know which version of what makes a difference? **A**: That's an excellent question. We all need to do a better job of

keeping track of what hardware/software experiences which kids had.

5. **Q**: Doesn't it take thousands of cases to do good research? Our district(school) isn't that big? **A**: With well constructed samples, it is possible to generalize to the population from surprisingly small numbers of respondents. Selecting those sampling dimensions (and getting access to schools, teachers and children) is one of the places where the client organizations can be helpful.
6. **Q**: How can you say for sure that IT "caused test score gains"? **A**: Strictly speaking, none of us can make that claim on the research designs that are practically feasible. But social science research is seldom if ever causal. One way or the other, decision makers have to commit their organizations. We try to help with the best data from the most powerful designs we can get.
7. **Q**: If somebody outside the school district pays for the study, then it isn't objective. **A**: We do lots of studies paid for by third parties. The question is not, who paid for it, but how was it done. We always report our methods (sample, data collection instruments and techniques, analysis procedures) and we make that publicly available. If everyone follows the rules of science and if the study followed those rules, then the objectivity is there regardless of the auspices.
8. **Q**: It takes millions of dollars to do good research. **A**: Research that ends up with compelling results is sometimes costly. But we find that districts and schools will help with data collection, they do part of the work of mailing, they critique procedures and generally share costs to make things feasible at modest prices.
9. **Q**: The most important question is, does IT change the act of teaching? How can you find that out? **A**: We believe in multiple methods. That's why most of our work is quantitative/qualitative (or vice versa) in successive waves. Lots of people think that IT can help teachers use more constructivist methods and we have been developing and refining item banks to measure just that---the shift from instructivist to constructivist.
10. **Q**: Evaluations are always ignored. **A**: Some are. It depends on how directly (and simply) the reports and the underlying data speak to the policy issues. And also on the patience of the policy makers and of the measurement people.

Selected Sources on Measurement of Instructional Technology

- International Society for Technology in Education (ISTE) (1998). *National Educational Technology Standards for Students.* Eugene, Or. (funded by the National Aeronautics and Space Administration (NASA) in consultation with the U.S. Dept. of Education; the Milken Exchange on Education Technology; and Apple Computer, Inc.) (www.iste.org).
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[New Directions in the Evaluation of the Effectiveness of Educational Technology]

The Idaho Technology Initiative:

An Accountability Report to the Idaho Legislature

Report	PDF 395K
Appendix 1 Insert (*Data Plan*)	PDF 21K
Appendix 2 Insert	PDF 5K
Appendix 3 Insert	PDF 7K
Appendix 4 Insert	PDF 14K
Form A Phase II: District Questions	PDF 5K
Form B Phase II: District Questions Research Study Form	PDF 2K
Dissertation (report subject)	PDF 319K
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To the Top

Local Advisory Committee Member Handbook

Improving Professional-Technical Education through Business, Industry and Education Cooperation PDF 39K

To the Top

IDAHO COUNCIL FOR TECHNOLOGY IN LEARNING

The Idaho Technology Initiative:
An Accountability Report to the Idaho Legislature on the effects of monies spent through the Idaho Council for Technology in Learning

Prepared by

The State Division of Vocational Education
The State Department of Education, Bureau of Technology Services

January 1, 1999

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Table of Contents

List of Figures

List of Tables

List of Appendices

Abstract

In 1994 the Idaho Legislature passed HB 901, the Idaho Technology Initiative. The initiative provided for one-time and ongoing monies for the purchase and integration of technology into the K-12 public school systems. Between the years 1994 and 1998, $10.4 million per year has been allocated to Idaho's K-12 public school systems, an average of ***$42.55 per student, per year, or $212.75 per student over the five-year period.***

In addition to providing monies for technology, the initiative provided for the creation of an administrative council to be established under the State Board of Education. The administrative council, named the Idaho Council for Technology in Learning (ICTL), created eight specific goals for technology in Idaho's schools by which to evaluate the impact of the State's investment, and fulfill the Legislative charge which specifically requires the ICTL to accomplish the following:

1) Develop statewide performance indicators
2) Address impact, costs, and benefits of projects funded through the ICTL
3) Track progress and funds spent to achieve indicators

This report explains the design of the plan created to accomplish this charge which uses statewide tests, research studies, student surveys and technology examples to measure the effectiveness of technology in the Idaho's public schools. The following questions were asked and answered:

Goal - Integration of Technology
Have students improved their academic performance as a result of the integration of technology in Idaho's K-12 schools?

> **Answer** -- There is a ***positive relationship*** between ***academic performance*** in core studies, language, math, and reading and the ***integration of technology*** in Idaho's K-12 schools (See Page 3).

Have Students improved their technological literacy as a result of exposure to technology?

> **Answer** - Both 8th and 11th Grade groups ***increased*** their technological literacy as a result of exposure to technology (See Page 20).

What technology-related factors have the greatest impact on academic gain in Idaho's schools?

> **Answer** - The combined top six factors for 8th and 11th grade students are: the ability of the student to choose the appropriate software tool for completing a project, amount of computer use at school, exposure to Internet and email use, amount of computer use at home, use of technology for class projects, and use of software to simulate "real-life" experiences (See Page 22).

Goal - Compatibility
Have schools been able to share information and resources through the use of technology?

> **Answer** - Results from the school districts revealed ***extensive use*** of Internet and email by both teachers and students in addition to moderate use of Idaho's Distance Learning facilities (See Page 23).

Goal - Teacher Preparation
Have schools and colleges of education worked together to effectively prepare teachers to teach using technology?

> **Answer** - Schools and colleges of education ***have*** worked together to effectively prepare teachers to teach using technology (See Page 26).

Goal - Collaboration with Communities and Businesses
Have schools involved community members, businesses, and postsecondary institutions in the implementation and use of technology in schools?

> **Answer** - Community members, businesses, and postsecondary institutions ***have*** made significant investments and have been involved in the implementation and use of technology in schools (See Page 30).

Goal - Technology Systems Enhancing the Efficient Operation of Idaho Schools
Have schools used technology to improve administrative efficiency in school operations?

> **Answer** - Schools ***have*** used technology such as email, Internet, and electronic data storage to improve administrative efficiency in school operations (See Page 32).

Goal - Training of Students to Maintain Technology
Are students able to install, maintain, and support technology?

> **Answer** - Students ***have*** been given the opportunity through the Technology Support Technician Program to install, maintain, and support technology (See Page 34).

This report clarifies issues surrounding the debate over whether the use of technology in Idaho's schools has had a positive impact on students. The benefits of technology in teaching and learning are clear: increased academic achievement, improved technology literacy, increased communication, well-trained, innovative teaching, positive relationships with the community, more efficient operation of schools, and technically qualified students ready to enter today's workforce.

By appropriating funds, through the Idaho Technology Initiative, the legislature has made a valuable investment in Idaho's future which has paid and will continue to pay great dividends as shown in comparisons between Idaho and the nation. Moreover, the funds distributed to districts thus far have made it possible for Idaho schools to create a base upon which to build infrastructures such as technology hardware and software, compatible network infrastructure, timely teacher and student training which are key to providing for our students' needs in the 21st century.

Introduction

In 1994 the Idaho Legislature passed HB 901, the Idaho Technology Initiative. The initiative provided for one-time and ongoing monies for the purchase and integration of technology into the K-12 public school systems. Between the years 1994 and 1998, $10.4 million per year has been allocated to Idaho's K-12 public school systems, an average of $42.55 per student, per year.

In addition to providing monies for technology, the initiative provided for the creation of an administrative council to be established under the State Board of Education. The administrative council, named the Idaho Council for Technology in Learning (ICTL), created eight specific goals for technology in Idaho's schools by which to evaluate the impact of the State's investment, and fulfill the Legislative charge.

Legislative Charge to the ICTL

The legislative charge to the Idaho Council on Technology in Learning (ICTL) is as follows:

> "The Idaho Council on Technology in Learning will develop statewide performance indicators to address the legislative intent of the impact, costs and benefits of the projects funded by the Idaho Council on Technology in Learning. The performance indicators will be used to track progress and funds spent to achieve performance indicators. A report of the funds expended to attain the performance indicators will be provided to the legislature and the State Board of Education annually."

The intent language provided by the legislature specifically requires the ICTL to accomplish the following:

1) Develop statewide performance indicators[1]
2) Address impact, costs, and benefits of projects funded through the ICTL
3) Track progress and funds spent to achieve indicators

The Data Collection Plan

The design of the plan uses statewide tests, research studies, student surveys and technology examples to measure the effectiveness of technology in the Idaho's public schools. Data collection was divided into three levels (tiers) and each level of data was used to answer a key question for the eight ICTL Goals[2]. The tiers are as follows:

> Tier One–An assessment which measures the relationship of technology on academic gain and *can be generalized across the Statewide population* of

[1] See appendix (data collection summary) for individual performance indicators.

[2] ICTL goals five and eight were combined due to similarity in content and intent. ICTL goal six, evaluation, is being fulfilled by the completion of this study.

Idaho's K-12 public school students.
Tier Two–Reporting of regional technology studies which target specific learning outcomes.
Tier Three–Reporting of descriptive examples supporting regional and statewide assessments.

Effectively, the marriage of the three tiers of the data, via the collection design, provides "the big picture" -- an ample blueprint of the effect of the investment in technology in education between the years 1994-98.

ICTL Answers to Legislative Questions

Goal - Integration of Technology

Question 1 -- Have students improved their academic performance as a result of the integration of technology in Idaho's K-12 schools?

Answer --A ***positive relationship*** between ***academic performance*** in core studies, language, math, and reading and the ***integration of technology*** can be shown in Idaho's K-12 schools.

Cost - As reported by Idaho School Districts, the amount of ICTL monies expended to achieve ICTL Goal One, Integration in the 1997-98 school year, represents 36.26% of the total ICTL dollars allocated.

Evidence

Tier One (student testing) - The question addresses if there is a relationship between technology and academic gain and if so, what it might resemble.

The Methodology of the study follows:

Subjects

The population, from which the sample was drawn includes approximately 244,400 K-12 public school students, in the State of Idaho, who are enrolled in the 1998-99 school year. The target sample population of 35,885 8th and 11th grade students, was comprised of 18,493 males and 17,392 females.

Groupings

The subjects comprising the sample can be categorized into two distinct groups:
Group One - Those who were in the 4th grade in 1994 and who are currently in 8th grade and will be taking the ITBS exam in October.
Group Two - Those students who were in 8th grade in 1995 and who are currently in 11th grade and will be taking the Test of Academic Proficiency (TAP) in 1998.

The 1994-95 and 1995-96 school years were used as the initial data points by which to track student progress over the four years in which monies were made available to districts through the ICTL. Two groups of students were chosen to include in the sample, the first to reflect participants who were enrolled as elementary students from 1994-98, and the second to reflect those participants who were enrolled as secondary students from 1995-98. Both groups were used to ensure the sample data collected would better represent the population than the use of only one secondary or elementary group. Additionally, the use of two groups takes into account the varying disbursement of funding between and within the districts over the period of the study. For example, School District "A" may have determined that investing their monies in secondary student services was a stronger implementation rationale because high school students are closer to graduation and/or joining the workforce. School District "B" may have chosen to put monies at the elementary level first, and graduate towards the secondary level over time. By including two groups both integration strategies will be taken into consideration within the data collection model.

Data Matching/Elimination

The data collection was limited to include students who were in Group One and matched by name and birth date between 1994 and 1998 school years, or in Group Two who matched between 1995 and 1998. The strategy was to eliminate any students who emigrated or immigrated during the period of study. This reduced the number of students in the sample. (n = 26,122)

Instruments

Few assessment tools are currently available in Idaho *for use statewide*. The following is a summary of the choice of assessment instruments and the rationale for such decisions. Criteria for choosing a statewide assessment instrument follow:

Criterion 1 -- The measurement instrument had to be used statewide consistently between the years 1994 and 1998.
Criterion 2 -- The measurement instrument could not have any major modifications during the years 1994-1998.
Criterion 3 -- The measurement instrument must have met the tests for reliability and validity.
Criterion 4 -- The measurement instrument must have been designed to collect data which can be generalized statewide.

As a result of the following analysis, the measurement instruments that were chosen for this study include:

1) • ITBS exam scores for Idaho students in the 4th grade in 1994 and 8th grade in 1995, as well as Iowa Test of Basic Skills (ITBS) exam scores for Idaho school students in the 8th grade in 1998.

2) Test of Achievement and Proficiency (TAP) exam scores for Idaho students in 11th grade in 1998.

In addition to the measurement instruments, a ten-question self-reporting student survey was designed to measure technology exposure.

The Iowa Test of Basic Skills (ITBS) Exams

The ITBS is a nationally recognized standardized test of academic achievement consisting of a battery of assessments in vocabulary, reading comprehension, word study, language skills, mathematics, social studies and science. The test has been in existence for 63 years and has a reliable track record (Hoover, 1994). The information from the battery is unique in the fact that it cannot be obtained from other sources (Hoover, 1994). The Iowa Test of Basic Skills was developed in 1935 at the University of Iowa College of Education to help teachers determine knowledge levels of their students, for planning instructional goals and approaches, to provide achievement information to monitor student's progress year-to-year, to provide a basis for reporting to parents, and to identify areas of strength and weakness of groups as they relate to curriculum. Subsequently, the exam has been used for reports to administrators, principals and others for making decisions related to many aspects of the educational process.

Norms

The term "norm" refers to a set of scores that are used to make interpretations. National norms are scores from a nationally representative sample of students, while local norms originate from local school districts. The tests for the subject areas on the ITBS have been standardized with the same group of students, and have been obtained from a single group of students at each grade level. The use of norm groups generally allows the evaluator of the student data to make general statements about the student skill strength in tested areas, as well as to allow students to be compared to other students, and schools to other schools (Hoover, 1994 pp.55-56). Idaho has changed the norm group used once since the 1993-94 school year. The national norm group used over the period of study is the Fall 1992 group.

The Test of Achievement and Proficiency (TAP)

The 1992 edition of the Test of Achievement and Proficiency, used by Idaho, was designed to measure the ability of the student to use information, emphasizing critical thinking skills to a greater degree than previous editions. The survey battery includes the following sections: 1) Reading Vocabulary; 2) Reading Comprehension; 3) Written Expression; 4) Math Concepts and Problem Solving, and 5) Math Computation (optional) (Riverside, 1994).

The ITBS/TAP assessments were chosen for the following reasons:

First, to meet Criterion 1, the measurement instrument has been used consistently between the years 1994 and 1998. As seen in Table 1, the model which will be used is a four-point data comparison model. The critical years for data collection are 1994-95, 1995-96 and 1997-98. There will be two base years (data points). The first data point 1994-95 will be the base on which students who were 4th graders in 1994-95 will be tracked through the second data point, 8th grade in 1998-99. The 1995-96 year will be used as the third data point in which students who were in 8th grade in 1995-96 will be tracked through the fourth data point, 11th grade in 1998-99.

Table 1
Pre- and Post-test Data Points for the Iowa Test of Basic Skills

	Data Point	Pre-Year	Pre-Year Grade	Data Point	Post-Year	Post-Year Grade
Group 1	1	1994-95	4th Grade	2	1998-99	8th Grade
Group 2	1	1995-96	8th Grade	2	1998-99	11th Grade

There are two types of tests given in any year - the survey battery or the complete battery. As seen in Table 2, the survey battery was taken by students in the 4th grade in the 1994-95 school year and the 8th grade in the 1995-96 school year. Both the 8th and 11th grade students will take the survey battery in 1998, which will provide for our third and fourth points for data comparison.

Table 2
Iowa Test of Basic Skills Descriptive Information

School Year	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Norms	Spring 88	Fall 92	Fall 92	Fall 92	Fall 92	Fall 92
Grades Tested	6, 8, 11	4, 8, 11	3-11	3-11	3-11	3-11
Dates Given	March	October	October	October	October	October
Type of Test	Comp. Battery	Survey Battery	Grades 3, 5, 6, 7, 9, 10 took Complete battery. Grades 4, 8, 11 took Survey.	Grades 3, 5, 7, 9 took Complete battery. Grades 4, 6, 8, 10, 11 took Survey.	Grades 3, 5, 7, 9 took Complete battery. Grades 4, 6, 8, 10, 11 took Survey.	Grades 3, 5, 7, 9 took Complete battery. Grades 4, 6, 8, 10, 11 took Survey.

Next, Criterion 2 was met as a result of the consistency of the measurement instrument. The instrument did not have any major revisions during the years 1994-1998. As seen in Table 2, the test examination date was standardized in the 1994-95 school year. The change to the October examination date gave enough continuity to the testing schedule that the data could be collected starting in the 94-95 school year for those students who currently are in the 8th grade and the 95-96 school year for those currently in the 11th grade. As seen in Table 3, there have been no significant modifications since 1994-95.

Table 3
Modifications in ITBS 1993-1999

1995 - Change in grades tested (does not effect grades 4,8)
1994 - Change in norms from Spring 1988 to Fall 1992
1994 - Change in examination date from March to October
1993-96 - Changes in exam types given to various grades

Next, Criterion 3 was met as a result of the measurement instrument meeting the tests for reliability and validity. The ITBS/TAP tests are a nationally recognized standardized achievement battery which has been used for over 60 years by many states to provide information to improve instruction (Hoover, 1994). The KR-20 (Kuder-Richardson) reliability of the Iowa Test of Basic Skills refers to the internal consistency test for reliability. As seen in Table 4, the reliability of the ITBS is .85 for grades K-8 for the Fall testing in years 1994-98 (Riverside, 1994).

Table 4
Reliability of Iowa Test of Basic Skills 1994-98 (based on 1992 Standardization)

Instrument	Reliability Coefficient (KR-20)
Grades K-3 Fall	.85
Grades 3-8 Fall	.85

As seen in Table 5, the KR-20 reliability of the TAP ranges from .829 to .950 depending on the subject.

Table 5
Reliability of Test of Achievement and Proficiency 1998-Standard Scores

Instrument	Reliability Coefficient (KR-20)
Test of Achievement and Proficiency (TAP)	.829-.950

The State of Idaho uses the ITBS/TAP exams as valid measures of academic achievement. Content validity of the ITBS/TAP is ensured by Riverside Publishing through a rigorous set of development steps including: 1) developing content specifications; 2) editorial review, and 3) field testing (Riverside, 1994 pp.11-14).

Last, Criterion 4 was met as a result of the measurement instrument's design. The ITBS/TAP exams are the standard set by the Idaho State Department of Education for the statewide evaluation of student performance (Personal Communication, Tiel 1998).

The Student Technology Exposure Questionnaire

A survey was developed to measure the technology exposure students had experienced over the four-year period under study. The procedure follows:

1) Development of the survey
2) Beta testing the survey
3) Revision of the instrument

The technology exposure questionnaire was developed using International Society for Technology in Education (ISTE) standards, a nationally recognized technology standard. ISTE recently released the National Education Technology Standards (NETS) for students (ISTE, 1998). A group of Idaho technology experts was assembled, including regional technology advisors from colleges and universities, parents, teachers, State officials, and students to use the NETS objectives to create a self-reporting student exposure questionnaire which was used to measure the amount of perceived exposure to technology a student had between the years 1994-1998.

The questionnaire was then pilot tested on 8th and 11th grade classes and tested for statistical reliability using the Cronbach's Alpha test, where (n=107). The results were used to choose the questions with appropriate content having the greatest reliability. Then, in October of 1998, the questionnaire was given to all Idaho 8th and 11th grade students who took the

ITBS/TAP exams. The student answers to the exposure questions were recorded in the student identification box on side one of the ITBS/TAP answer sheet.

Riverside Publishing was contracted to deliver a CD Rom or series of diskettes which contained the data from all three instruments (Table 6). This data provided the responses of all students in the sample on each of the 10 questions in the exposure survey, archived data from ITBS exams for all Idaho students in 4th and 8th grade in the 1994-95 and 1995-96 school years respectively, and data from all ITBS/TAP exams for Idaho students in 8th and 11th grade in the 1997-98 school year.

Table 6
Riverside Publishing Reported Data

Item
Grade (Based on post-test grade 11 or 8)
System Name (District)
Building Name (Based on post-test grade 11 or 8)
Response to 10 survey questions
ITBS/TAP Post-test Scores
Reading Total SS
Language Total SS
Math Total SS
Core Total SS
ITBS/TAP Pre-test Scores
Reading Total SS
Language Total SS
Math Total SS
Core Total SS
ITBS/TAP Gain Scores
Reading Total SS
Language Total SS
Math Total SS
Core Total SS

The questionnaire data was imported into the Statistical Program for Social Sciences (SPSS) and the variables were plotted to determine the natural groupings. The data was analyzed and categorized into three groups, the first comprising the high exposure group, the second comprising the medium exposure group, and the last comprising the low exposure group. For example, students who answered the 10 technology exposure questions with a high degree of perceived exposure were classified into a "high exposure" group. Similarly, those students who perceived a medium and low exposure to technology respectively were classified.

Procedures

The study seeks to determine:

1) Whether students have increased their technological literacy as a result of exposure to technology in Idaho schools over the four-year period of study.

2) Whether there is a relationship between exposure of students to technology and student academic achievement in Idaho schools over a four-year period.

3) Which technology factors have the greatest impact on academic gain in Idaho's schools.

To make such a determination is a four-step process:

1) Identify Academic Gain -- demonstrate student achievement using the Iowa Test of Basic Skills (ITBS) gain scores of two groups of Idaho students over the four years of study.

2) Identify Technology Exposure -- identify the technology exposure of the students within this time period.

3) Identify the Academic Gain and Exposure Relationship -- correlate student academic gain with technology exposure.

4) Identify Technology Factors – identify which technology factors explain the greatest amount of academic gain.

Data Analysis

Analysis Model

Multiple Analysis of Variance (MANOVA)[3] was conducted on the data to accomplish the following:

1) Identify differences in ITBS/TAP scores between groups at grades 8 and 11, and
2) Compare each group's ITBS/TAP core, language, math and reading scores to each other.

The purpose of using the MANOVA within the research design is to help determine whether the observed differences in the samples could be attributed to the natural variability

3 Multiple comparison procedures are designed to protect the researcher from calling differences significant when they really are not [Norusis, No Date #84] p. 291.

among the sample means or whether there was a reason to believe that some of the three exposure groups (high, medium, or low) had different values in the population with regards to academic gain. The following was tested:

Hypothesis

H_0 There are no significant differences in high, medium, and low exposure groups with respect to academic gain on ITBS/TAP core, reading, language, and math sections.

H_1 There are significant differences in high, medium, and low exposure groups with respect to academic gain on ITBS/TAP core, reading, language, and math sections.

By testing the hypothesis, we have determined the variability in the sample values. We studied how much the observations within each group varied as well as how much the group means varied. After the MANOVA (multi-variate analysis) was run for both the 8th grade group and the 11th grade group, an ANVOVA (uni-variate) was run on each area of the ITBS/TAP, reading, math and language[4]. Finally, a Tukey post-hoc analysis was run to assess the differences between the high/low, medium/low, high/medium groups.

Independent Variables

The High, Medium, and Low Technology Exposure Groups were used as the independent variables in this study.

Dependent Variables

The Math, Reading, Language, and Core ITBS/TAP subtests were used as the dependent variables.

Results

The following are the results of the analysis of Idaho student Core, Math, Reading and Language ITBS/TAP scores in relation to the three groups of students identified (high, medium and low exposure to technology).

[4] A test used to determine if several independent population means are equal.

Table 7
8th Grade ITBS Effect Size Difference Low/High Group Exposure by Subject

	8th ITBS Core	8th ITBS Reading	8th ITBS Math	8th ITBS Language
Effect Size	0.24	0.23	0.23	0.19
Months of Academic Increase (4-years)	2.40	2.30	2.30	1.90
Months of Academic Increase (12-years)	7.20	6.90	6.90	5.70

As seen in Table 7, a comparison of students in the high and low exposure groups reveals that Idaho 8th grade students who reported experiencing high exposure to technology, experienced academic gains in core, reading, math and language ranging from .19 to .24 over those students who reported low exposure to technology. All groups showed that there were statistically significant differences between groups where $F(8, 23906) = 14.13$, at $P < .001$.

Effect Size was calculated for each group comparison using the formula ES=$\underline{M}_1$-$\underline{M}_2$/$\underline{s}$, where $\underline{M}$ represents the mean scores respectively of the high and low exposure groups, and summarizes the general degree of outcome between the two groups. Cohen (1988) reports in his work, *Statistical Power Analysis for the Behavioral Sciences (2nd Ed.)* that the effect size R^2 can be labeled by category for analysis purposes. When using MANOVA the following ranges apply:

Small but significant effect	= .2 SD separating the group means (r^2 =.01)
Medium effect	= .5 SD (r^2 = .059)
Large effect	= .8 SD (r^2 =.138)

By using Cohen's work on meaningful effect sizes, we see that both 8th and 11th grade Effect Sizes measure large enough to be considered as practical and meaningful.

According to Rogers (1991), Glass, McGaw, & Smith (1981), effect sizes which represent ability groupings can be extrapolated into months of academic gain. For example, the 8th grade core sample shows an ES = .24. This figure when converted shows an academic gain of 2.4 months of those students in the high exposure category as compared to those in the low exposure category over the four years of study. It can be inferred that for an 8th grade student who experiences high exposure to technology, over a 12-year school career, an academic gain of a little less than a school year (7 months) can be achieved through the integration of technology into the classroom.

Table 8
11th Grade ITBS/TAP Effect Size Difference Low Exposure Group/High Exposure Group by Subject

	11th TAP Core	11th TAP Reading	11th TAP Math	11th TAP Language
Effect Size	0.19	0.20	0.10	0.10
Months of Increase (3-Years)	1.90	2.00	1.00	1.00
Months of Academic Increase (12-years)	7.60	8.00	4.00	4.00

The 11th grade students who were reported in the high exposure group in the sample, similar to the 8th grade, show academic gain in all four areas. Initially, the gains for the 11th grade group seem smaller; however, it must be noted that the period of the 11th grade study was only three years, while the 8th grade was four. For example, we find that over the three years of study students who reported high exposure to technology when compared to the low exposure group show 2 months of academic gain in reading. Again, it can be inferred that over the career of the student receiving high exposure to technology approximately 8 months can be gained in reading over a 12- year period.

A Tukey post-hoc revealed that there were statistically significant differences where $P < .001$ between the low exposure and high exposure in the core, language, math, and reading groups. However, in the language and math groups no statistical significance was shown between the medium and high groups, and low and medium exposure groups respectively.

Tier Two (technology studies)

In order to evaluate the relationship of integration between the teacher/student use of technology and student learning, state institutions of higher education undertook numerous studies using several public schools, different grade levels, and a variety of curricula. Completed studies were conducted using pre- and post-test assessments. There are, however, several studies still in progress at this time. The following is a synopsis of the studies:

Table 9
Boise State University Research Studies

Study	Area Studied	Type of Study	Result
BSU #1	Science/Multimedia	Quasi-Experimental	Positive Academic Gain
BSU #2	Vocabulary Development	Experimental	Positive Academic Gain
BSU #3	Mathematics	Experimental	No Significant Gain
BSU #4	At-Risk Students	In Progress	In Progress
BSU #5	At-Risk Students	In Progress	In Progress
BSU #6	Special Needs Students	In Progress	In Progress
BSU #7	Social Studies	Experimental	No Significant Academic Gain
BSU #8	Telecommunications/Writing	In Progress	In Progress
BSU #9	Science/Databases	In Progress	In Progress
BSU #10	Writing	In Progress	In Progress
BSU #11	Technical Writing	In Progress	In Progress
BSU #12	Integration Vs. Lab Instruction	In Progress	In Progress

(Contact: Carolyn Thorsen)
Number of studies = 12
Number of studies completed = 4
Number of studies in progress =8
Studies showing positive academic gain = 2
Studies showing no academic gain = 2

Example:
Lead Researcher: Del Siegle

The Impact of Presentation Software on Secondary Science Students' Achievement and Attitudes (Glenn's Ferry High School)

Two groups (A&B) of Anatomy and Physiology students were involved in a study using laptop computers. The computers were made available to Group A during the first half of the year while Group B did not have access. For the second half of the year the procedure was reversed with Group B having access to the computers while Group A was without. Continuity was maintained between the two classes by using the same teacher, identical curriculum, and teacher-generated tests to measure student achievement. Interestingly, after Groups A and B rotated, the students in Group B made up the deficit in test scores as compared to Group A. Differences between the groups were clearly evident. Students using computers scored an average of a full grade (i.e. A to B) higher than students not using them.

Table 10
Idaho State University Research Studies

Study	Area Studied	Type of Study	Result
ISU #1	Math/Problem Solving	In Progress	In Progress
ISU #2	Geography Database	In Progress	In Progress
ISU #3	Math	Quasi-Experimental	Positive Academic Gain
ISU #4	Teaching Styles	In Progress	In Progress
ISU #5	Teacher Attitudes	In Progress	In Progress

(Contact: Al Strickland)
Number of studies reported= 5
Number of studies reported completed = 1
Number of studies in reported in progress = 4
Studies reported showing positive academic gain = 1
Studies reported showing no academic gain = 0

Example:
Lead Researcher - Dr. Al Strickland/Dr. J. Coffland
ISU Math Study

The aim of the ISU math study was to determine if the use of diagnostic teaching, math manipulatives, and computer-assisted instruction, properly used, would improve the achievement of 5th grade students in math. The study involved 22 fourth-grade teachers from 21 classrooms in nine southeast Idaho schools. Teachers were given year-long training while using math manipulatives, five computers per classroom, and appropriate math software for 4th grade math instruction. Student gain over the year was measured with the Stanford Diagnostic test - which showed an average student gain in math concepts of 16 percentile points, and the ITBS test - which showed an average gain of 18.9 percentile points between students' fourth and fifth grade scores.

Table 11
University of Idaho/Lewis and Clark State College Research Studies

Study	Area Studied	Type of Study	Result
Moscow #1	Internet	Experimental	No Statistical Significance
Moscow #2	Enhancement Aids	Quasi-Experimental	Positive Difference
Moscow #3	Mathematics/Hypermedia	Quasi-Experimental	Positive Difference
Moscow #4	Writing Skills	In Progress	In Progress
Moscow #5	Desktop Video Conferencing	Descriptive	Positive
Moscow #6	Desktop Video Conferencing	In Progress	In Progress
Moscow #7	Internet	In Progress	In Progress
CDA #1	Teacher Computer Efficacy	In Progress	In Progress
CDA #2	Teacher Development	In Progress	In Progress
CDA #3	Integration	In Progress	In Progress
CDA #4	Mathematics	In Progress	In Progress
CDA #5	Mathematics	In Progress	In Progress
CDA #6	Professional Development	In Progress	In Progress

(Contact: Dr. John Davis/Dr. Heidi Rogers)
Number of studies = 13
Number of studies completed = 3
Number of studies in progress =10
Studies showing positive academic gain = 2
Studies showing no academic gains = 1

Example:

Investigating the Use of Microcomputers as Enhancement Aids to Facilitate Lessons by Teachers

The 53 elementary students participating in the study were divided into experimental and control groups, and similar instruction was delivered to both groups. Following instruction, students in the experimental group used appropriate software for practice activities, while those in the control group used traditional worksheets and workbook activities as enhancement aids. The Iowa Test of Basic Skills was used to gather pre- and post-test data. Statistical analysis favored computers as effective enhancement aids to the content areas of mathematics and language arts.

As seen above, of the 30 research studies initiated by the institutions of higher education, 8 studies were completed and 22 are still in progress. Results of the studies were mixed -- of the 8 studies that were completed 5 show positive academic gains as a result of the integration of technology, while 3 studies show no significant gains. Positive gains were found in the areas of math, video conferencing, enhancement aids, science and vocabulary development. No significant academic gains were found in the studies targeting social studies, mathematics, and Internet. It is important to note that the results rely heavily on the type, controls, and methodology of each study.

Some Idaho school districts chose to conduct studies on the effects of technology in learning locally. Thirty studies were attempted, ranging in type from experimental to survey. Although many of the studies had questionable methodology and controls, overall positive results were found in the studies which were reported as complete.

Table 12
Idaho K-12 School District Studies

District	Area Studied	Type of Study	Result
Boise	Reading	Quasi-Experimental	Positive
Hansen	Math, Lang Arts, Reading	In Progress	In Progress
Shoshone	Reading	Quasi-Experimental	Positive
Valley	Math	Descriptive	Positive

Contact (ICTL Staff–State Department of Education)
Number of studies reported = 30
Number of studies reported complete = 18
Number of studies reported in progress =11

Boise School District #1

Using the Waterford Early Reading Program, 155 students in two schools were involved in a study designed to evaluate the impact of specific software on the learning process. Control and experimental groups were used and pre- and post-tests were administered. The results of the study indicated that the group using the Waterford program outperformed the control group.

Shoshone School District #312

Students in grades 8 and 12 were used in this study to determine if technology had an effect on reading achievement scores. The STAR reading assessment test was used as a pre- and post-test measurement instrument. Students working with programs enhanced by technology demonstrated overall improvement of 1.05 grade levels in one school year. Students in grades 12 demonstrated an increase of 2.5 grade levels. ESL students showed steady improvement of at least a full grade and as much as 2.5 grade levels.

Additional examples are located in the Appendix.

Tier Three, (technology examples)

Included in this section are descriptive examples gleaned from the ICTL Phase Two Reports completed by school districts yearly. The examples focus on the benefits derived from the integration of technology and how it has affected student performance in the classroom.

Benefit Example One: Effect on Test Scores– Many school districts were interested in determining how technology had impacted various test scores over the past year. Nampa, Filer, Payette, and New Meadows reported examples of increased ITBS scores as a result of integrating technology. Additionally, as seen in Table 13, fourteen districts reported substantial increases in reading scores or a dramatic increase in library circulation as a result of the integration of software specific programs such as the Accelerated Reader program.[5]

Table 13
Accelerated Reader Reported Data as Reported by School Districts

District	Increase in Reading Scores	Increase in Library Circulation
American Falls	.75 grade levels in four months	200%
Bonner	N/A	225%
Buhl	N/A	Tripled
Burley	20%	N/A
Cottonwood	8 months in a 6 week period	200%
Middleton	N/A	22,980 Books
North Gem	.45 grade levels in 2.3 months	1,122%
Preston	N/A	500%
Ririe	1 grade level in 6 months	100%
Sugar-Salem	N/A	12,300
Swan Valley	1 grade level	200%
West Jefferson	Reported Increase	120%

Note: Other school districts reported gains in various areas such as mathematics, language arts (Soda Springs, Grangeville, Castleford), and ACT scores (Idaho Falls)

Benefit Example Two: Cooperative Learning- Students in the Kuna School District's Elementary/Secondary writing program "Writing Partners" use technology to work

[5] Murtaugh, Buhl, American Falls, Sugar-Salem, Lakeland, West Jefferson, Ririe, Cottonwood, Preston, Burley, North Gem, Middleton, Swan Valley and Bonner have reported increases in either reading scores, library circulation, and/or student time on task as a result of the use of the Accelerated Reader program.

collaboratively with other students on language arts projects. This program pairs 4th, 6th and 8th grade students with counterparts in the 11th and 12th grades. These students met face-to-face a couple of times at the beginning of the school year and then continued to collaborate on class projects over the course of the year using telecommunications to conduct peer editing online. Teachers have reported increased interest, motivation and quality in the students writing. More information is available on the district website: www kunaschools.org/writing.htm

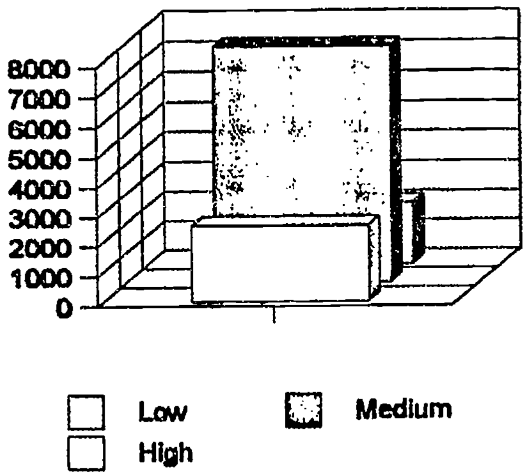
Additional examples are provided in the Appendix.

Question 2 – Have Students improved their technological literacy as a result of exposure to technology?

Answer: Both 8th and 11th grade groups increased their perceived technological literacy as a result of exposure to technology.

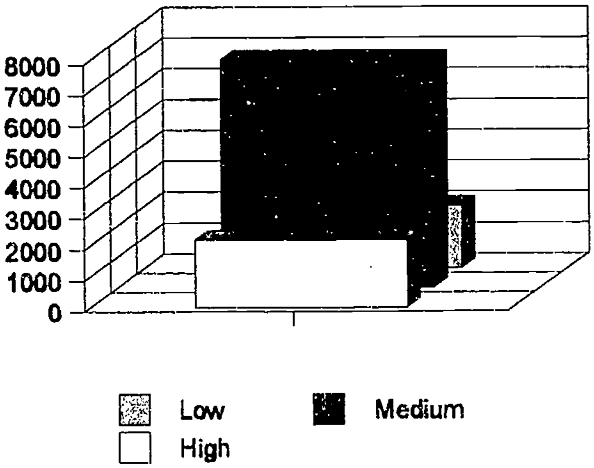
In October of 1998, students were asked to complete a technology exposure survey prior to taking the ITBS or TAP exams. The results of the survey revealed the amount of perceived exposure to technology the students had over the four years of study. As a result of their responses the students were categorized into three groups, high, medium and low technology exposure. The data from both 8th and 11th grade groups show that the majority of students reported moderate exposure to technology over the four years of study. The results of the survey are as follows:

Fig. 1: 11th Grade Exposure



As seen in Figure 1, out of 12,494 valid cases, 2,539 or 20.3% of the 11th grade students reported that they had experienced a *low* exposure to technology, while 7,892 or 63.2% of students reported a *moderate* exposure. Those students reporting a *high* exposure to technology represented 2,063 or 16.5% of students responding.

Fig. 2: 8th Grade Exposure



As seen in Fig. 2, out of 11,554 valid cases 2,176 or 18.8% of 8th grade students reported experiencing a *low* exposure to technology over the four years of study, while 7,367 or 63.8% of the students reported a *moderate* exposure. Those students reporting a *high* exposure to technology over the four years of study accounted for 2,011 or 17.4% of students reporting.

The data clearly shows that, although there are many students who still have not had the satisfactory exposure to technology, the majority of Idaho students have experienced moderate to high exposure to technology.

Question 3 - What technology factors have the greatest impact on academic gain in Idaho's schools?

Answer - The combined consistent high loading factors for 8th and 11th grade students were:

- The ability of the student to choose the appropriate software tool for completing a project;
- Amount of computer use at school;
- Exposure to Internet and email use, and
- Amount of computer use at home.

A stepwise regression analysis was conducted on both 8th and 11th grade groups, using gain scores for math, reading, core and language as the dependent variables and the 10 questions in the technology exposure survey as the independent variables. A regression formula was used

Where:
$\hat{Y}$= Gain Score Core, Gain Score Math, Gain Score Language or Gain Score Reading and $X_1 \ldots X_{10}$ = Technology Exposure Survey Questions.

The results of the regression reveal that the ability of the student to choose the appropriate software tool was consistently the highest loading variable in the regression, showing that it explains the greatest variance in the ITBS/TAP gain scores over the four years of study.

Second only to the ability to choose the appropriate software tool was the amount of computer use in school. One can infer that access to computers by students has a strong relationship to academic achievement. Interestingly, the amount of computer use at home also loaded consistently high, showing a relationship to academic achievement. Issues of access to computers at school and home should be a priority to educators as well as parents.

Two variables loaded high in the 11th grade regression analysis that did not show up in the 8th grade regression analysis: use of software to simulate real-world experiences and working together in groups, using technology to complete class projects and assignments. These two factors seem to be good indicators of academic gain in 11th grade, while not as prevalent in the 8th grade. It could be hypothesized that the difference may be either the result of differences in curricula at the various levels, style of teaching or the difference in maturity between the 8th and 11th grade groups.

Goal - Compatibility

The performance indicators chosen to measure the extent to which the school districts have been able to share information and resources through the use of compatible equipment are:

1) Number of local area networks;
2) Number of wide area networks;
3) Email use;
4) Internet use, and
5) Distance Learning use.

Question - Have schools been able to share information and resources through the use of technology?

Answer - Results from the school districts revealed extensive use of Internet and email by both teachers and students in addition to moderate use of Idaho's Distance Learning facilities.

Cost - As reported by Idaho school districts, the amount of ICTL monies expended to achieve ICTL Goal Compatibility in the 1997-98 school year represents 13.92% of total ICTL dollars allocated.

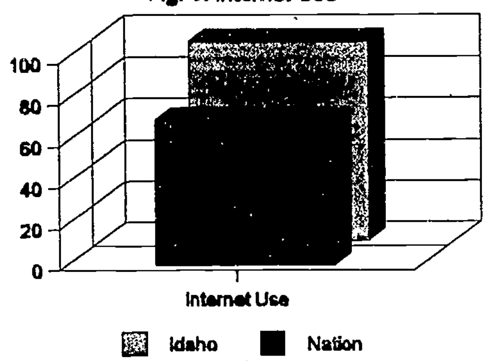
Evidence

Table 14
Compatibility Data as Reported by Idaho School Districts*

Item Surveyed	Participants
Students using district-provided email	66,461
Students using district-provided Internet	191,738
Teachers using district-provided email	12,960
Teachers using district-provided Internet	18,107
Distance Learning university to school	315
Distance Learning school to school	380

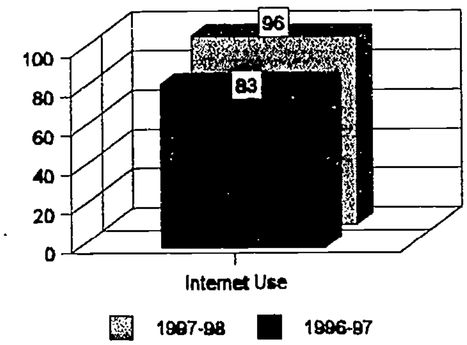
*Note: The Idaho K-12 student population is approximately 244,400 for school year 1998-99. There are approximately 15,000 certified teachers in the State of Idaho (Source Idaho State Department of Education).

Fig. 3: Internet Use



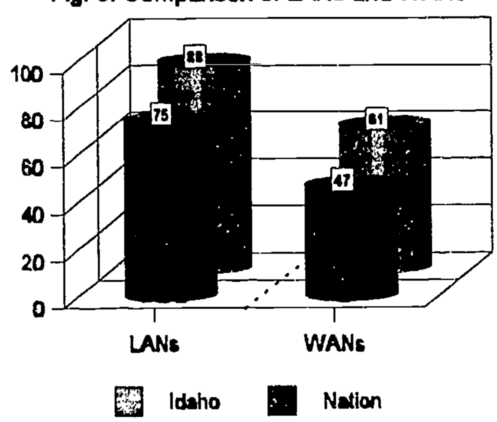
While the Internet is not a panacea for education's woes, it does provide immense resources to Idaho's schools which otherwise would remain untapped. The Internet provides rural as well as urban schools with the opportunity to go beyond merely being consumers of information. The Internet provides Idaho's students with the ability to become information producers and communicators through collaborative instruction, inter- and intra-school.

Fig. 4: Idaho Internet Use 1997-1998



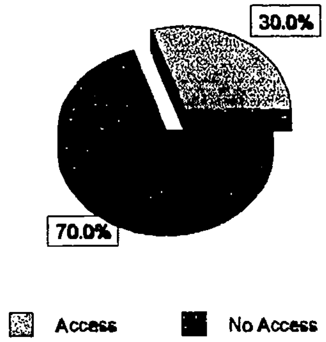
According to the the latest Market Data Retrieval (MDR) report, Internet access nationwide has increased dramatically; 85 % of schools now have Internet access compared to 70 % in 1997 and 32 % in 1996 (MDR, 1998). Idaho, in comparison, has increased Internet access 13% over the past year to 96% of schools, and ranks fourth in the nation in access, preceded only by Maine, Tennessee, and North Dakota (QED, 1998; MDR, 1998, p. 65).

Fig. 5: Comparison of LANs and WANs



As seen in Figure 5, connectivity within and among schools nationwide has significantly improved. Over 75% of schools reported using a LAN in 1998, while 44% of schools reported using a WAN (MDR, 1998). Again, Idaho reports above the nation in comparison, showing that 88% of school districts have LANs installed, approximately 1.9 per district, while 61% reported that they use a WAN to communicate (QED, 1998).

Fig. 6: Student Email Access



A quick comparison of QED to MDR data reveals that Idaho ranks ninth in the nation for schools using WANs (QED, 1998; MDR, 1998, p. 54).

As seen in Figures 6, 7 and 8, email use by teachers and students, non-existent only a few years ago, has made a tremendous impact in our schools. Nationally, 40% of teachers reported not having access to email (MDR, 1998). In comparison, approximately 84% of Idaho teachers reported having access to district-provided email, while the number of students with access was reported at approximately 30% (ICTL Phase 2, 1998).

Fig. 7: District Provided Email Access fo€

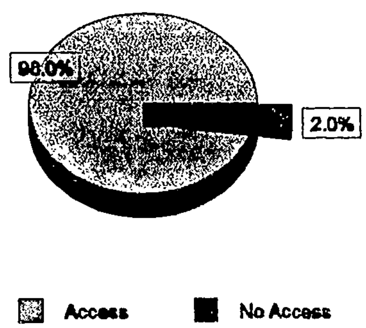


Fig. 8: Email Access Comparison Idaho and€

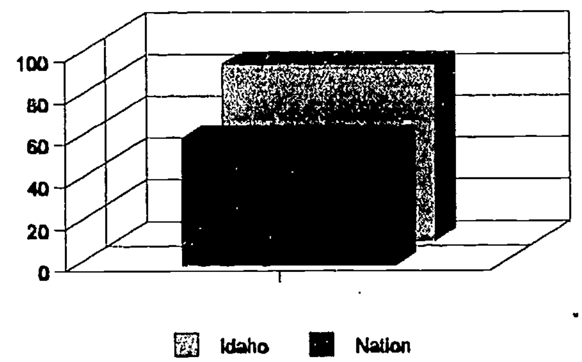
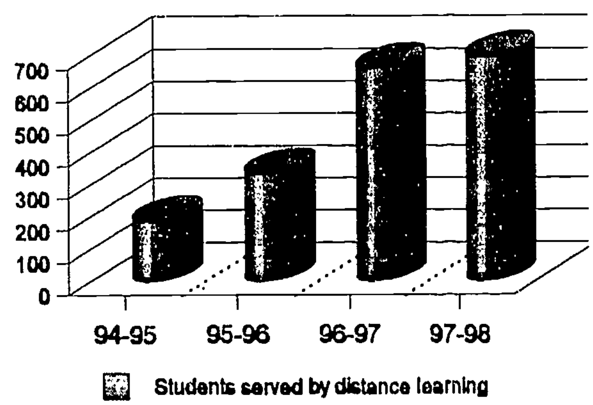


Fig. 9: Distance Learning Use



The analysis of the final performance indicator for compatibility, Distance Learning use shows that, with the addition of Federal monies to existing state dollars, a marked rise in Distance Learning can be seen between the 1994-95 school years and the 1997-98 school years.

Goal - Teacher Preparation

One of the most pertinent issues surrounding the integration of technology into existing curricula, nationally as well as in Idaho, is teacher preparation and staff development. The colleges of education and school districts in Idaho have instrumental roles in preservice education, carrying the responsibility of providing professional development for the teachers in the State of Idaho. The intent of ICTL Goal 3, Collaboration with Higher Education, is to help facilitate relationships between the colleges of education and school districts in these regards. The performance indicators chosen to measure the provision of preservice to school districts were:

1) Performance of Idaho Teachers on the Teacher Technology Certification;
2) Number of workshops offered to school districts by higher education institutions;
3) Total number of hours of instruction provided by each institution;
4) Number of inservice hours provided by school districts, and
5) Descriptions of exemplary teacher preparation.

Question - Have schools and colleges of education worked together to effectively prepare instructors to teach using technology?

Answer - Schools and colleges of education have been working together to effectively prepare instructors to teach using technology.

Cost - As reported by Idaho School Districts, the amount of ICTL monies expended to achieve ICTL Goal 3, Collaboration with Higher Education; in the 1997-98 school year represents 3.42% of the total ICTL grant dollars allocated.

Evidence -

Table 15
Performance of Idaho Teachers on Teacher Technology Certification[7]

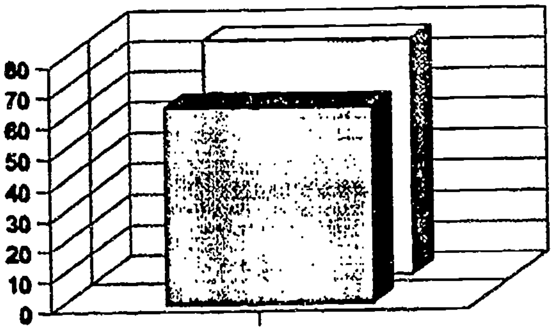
Institution	Taken Instrument	Passed Instrument	Taken Projected 1999	Taken Projected Total	Projected % Pass Rate
BSU	4,955	3,418	3,000	7,955	69%
ISU	30	30	76	106	100%
UofI/LCSC	137	105	1,450	1,587	77%
Totals	5,122	3,553	4,526	9,648	

[7]There are approximately 15,000 certified teachers in Idaho. These numbers do not include pre-service teachers

Table 16
Institution Inservice Data

Institution	Workshops	Hours
BSU	203	3,114
ISU	68	1,020
LCSC	43	872
UofI	77	468
Totals	391	5,474

Fig. 10: Comparison of Professional Training



As seen in Table 16, Idaho institutions of higher education have conducted 5,474 hours of training. An estimate can be made on the total number of training hours needed by multiplying the number of hours needed for pre-service teachers to certify (90) by the number of teachers certified in the state(15,000). To satisfy requirements needed to pass the assessments, Idaho teachers would need 1,350,000 hours of training assuming that no training had been conducted. We know for a fact that training is taking place through institutions of higher education as well as local school districts.

Nationally, 36% of schools offer no technology-related professional development (MDR, 1998, p. 109). As shown by district ICTL reports, many Idaho schools have conducted in-district inservice classes using their own training experts and facilities. The practice of providing the training in-district makes it difficult to quantify the actual time and resources a district allocates toward training of their teachers and staff. To help alleviate the problem, the ICTL asked the districts to report their contributions toward training by hour and individual for the 1997-98 school year. Idaho's school districts reported a total of 11, 942 teachers who participated in technology training for a total of 86,603 hours of training that could not be directly related to out-sourcing expenses. As seen in Figure 10, Idaho school districts reported on the whole that 77% of staff received some professional-technical training, while the national average is 64% (ICTL Phase 2, 1998; MDR, 1998, p. 109).

Descriptive Examples of Successful Teacher Inservice:
Example 1, Train-the-Trainer
(as reported by Donna Vakili, Boise State University)

A good example of technology-related training is the BSU Train-the-Trainer program. This program is an innovative collaboration between the BSU Educational Technology Outreach Program, an individual school district, and a teacher identified by the district as a potential technology trainer. It evolved two years ago as a way to expand the number of teachers trained by the BSU Educational Technology Outreach Program to meet the State-mandated challenge to train all teachers in Region 3, and to serve individual district needs. As the demands for effective technology training increase, it has become evident that these trainers play an important role in offering technology classes that meet the needs of educators. These trainers serve as technology advocates and integration specialists in their classrooms and can offer classes in educational technology that meet district goals and the needs of teachers. Not only do these trainers share a common knowledge of technology, but they also have developed a common vision for appropriate use of computers in the teaching/learning process.

The Train-the-Trainer Program is a field-based, two-year program which focuses on technology skills, integration strategies, adult learning, and methods for teaching technology classes. Classes are held in a school district in a 12-credit sequence and can be applied to a Master's Degree in Educational Technology or Curriculum & Instruction. A key component in the program is consistent follow-up and support by Boise State University to insure that the trainers do not feel isolated as they struggle to implement technology in their classroom and share these successes with others.

There are currently 124 trainers in Boise State University's Train-the-Trainer Program. They represent 18 school districts: Bruneau-Grandview, Emmett, Homedale, Idaho City, Kuna, Marsing, Meridian, Middleton, Midvale, Nampa, New Plymouth, Notus, Parma, Payette, Twin Falls, Vallivue, Weiser, and Wilder. These trainers have trained 1,299 teachers through either formal workshops or technology inservices from Fall '97 through Summer '98. It is anticipated that these trainers will impact over 1,700 teachers in the coming school year.

Example 2, Technology Inservice Project (University of Idaho-Moscow)

A workshop was held for elementary teachers at the Nez Perce School District; that focused on spreadsheet application. The goal of the workshop was to increase participants' skills, enabling them to begin to integrate spreadsheets into classroom instruction. The workshop focused on a specialized activity titled, "What's in the Bags: M&Ms." We have found that using this engaging and enjoyable activity is a great way to introduce teachers to spreadsheets. They attended to four tasks: get started with spreadsheets, find the average number of M&Ms in a bag, make an inference about the colors (quantity, percentage, etc.) in an M&M bag, and graph the results of their inquiry. As a result, the teachers (without being told) addressed the following specific objectives:

- Learn how to enter information (data) onto a spreadsheet template
- Create fundamental (arithmetic) calculation formulas and apply to data

- Modify and enhance cell entries with formatting styles
- Arrive at inferences concerning available data
- Graph results obtained from manipulated data

Teachers responded positively and enthusiastically to the workshop. They reported that they not only understood how to use the program, but also learned function application of the program in their classroom. Many indicated that, with limited additional effort, they would be able to teach their students to use spreadsheets to begin to manage, manipulate and analyze data using the M&M activity. Follow-up visits by the inservice trainer confirmed the effectiveness of the workshop, as many teachers had already begun to integrate spreadsheets into classroom instruction, and to use it as a data management tool. This is an example of many successful workshops coordinated by the College of Education, University of Idaho.

Example 3, Technology Inservice Project (University of Idaho-CDA)

A successful example of integrating multimedia into the elementary classroom took place in the Coeur d'Alene School District. A six-month series of multimedia training workshops was delivered to 12 elementary teachers. The sessions took place once a month on a selected Tuesday. Teachers were released from class for training from 8:00 a.m. until shortly after 3:00 p.m. The training sessions took place in four different elementary schools using different labs and equipment during each session. Final projects were saved and transferred to CD-ROM.

Participating teachers explored a different element of multimedia development during each of the first five months of training and were challenged to integrate the concepts into a final project. Training included use of equipment and peripherals, along with specific multimedia-development software training. Teachers explored the elements of digital audio, digital video, digital imaging, text elements, and interactivity in a variety of activities designed to introduce the basic skills necessary to begin a successful project. The Internet and its potential for contributing multimedia resources was also presented and explored. The teachers learned to search for graphics, text materials, audio samples and video clips to incorporate into their projects.

The final class projects were an impressive display of creativity and ingenuity. The projects were displayed at the Coeur d'Alene mall to shoppers taking the time to stop and interact with teachers and students about their projects. One of the viewers was the State Controller; he expressed amazement at the quality of the projects and the manner in which they were displayed at the mall. Many students and parents visited the mall to see the displayed projects. This multimedia training project proved to be a great success for the teachers and students involved, and serves as one of the models for effective educational technology training coordinated by the College of Education, University of Idaho.

Goal - Collaboration with Communities and Businesses

The intent of the ICTL Goal 4, Community Collaboration, is to encourage local districts to develop relationships with their community patrons, businesses, and postsecondary institutions, involving them in a collaborative educational process. Performance indicators chosen to measure the amount of interaction are:

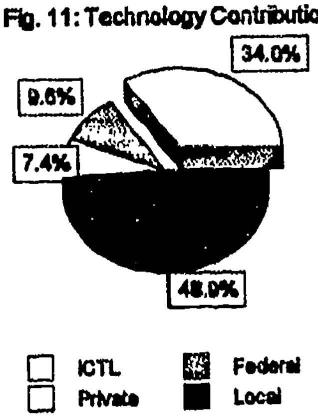
1) Monies generated through local technology bonds;
2) Monies generated through local technology levies;
3) Monies generated through grants, and
4) Monies generated through "other" donations.

Question - Have schools involved community members, businesses, and postsecondary institutions in the implementation and use of technology in schools?

Answer - Community members, businesses, and postsecondary institutions have been involved in the implementation and use of technology in schools.

Cost - As reported by Idaho school districts, the ICTL monies expended to achieve ICTL Goal, Collaboration with Community, Business and Postsecondary Institutions, in the 1997-98 school year represent 2.11% of the total ICTL dollars allocated.

Fig. 11: Technology Contributions



Evidence -

Each year since 1994, the ICTL has disbursed $10.4 million to Idaho school districts for installation and integration of technology in the K-12 public school system.

As seen in Fig. 11, 48.9% of contributions towards technology in 1997-98 originated from local districts. ICTL funding accounted for 34% while the remainder was made up of private, federal and other dollars.

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Table 17
District Contributions to Technology 1996-98

Type	1996-97	1997-98
Federal Grants	$1,467,555	$3,093,346
Private Grants	$328,650	$2,393,270
Local Technology Bonds	$201,356	$131,250
Local Technology Levies	$3,283,313	$3,228,849
Local Tech Budget Provision	$9,663,073	$11,453,403
Other (Donations, PUC, etc.)	$5,630,296	$2,071,946
Totals	**$20,574,243**	**$22,372,064**

Table17 shows that as a result of ICTL funding, Idaho school districts have had the opportunity to involve patrons, local businesses and industry through bonds, levies and donations. As seen in Figure 11, the school districts have at least matched the ICTL contribution dollar for dollar.

Example, Integration and Job Opportunities-

Through support from the Division of Vocational Education as well as funding through ICTL, many school districts have implemented Technology Support Technician Programs. These programs are designed to integrate the concepts of computer repair and network management into an industry-certified curriculum. Many school districts have realized the benefits of such a program by using their students to help install, troubleshoot and maintain the district's networks. Additionally, many of the students, after the first semester, have enjoyed paid work experiences either in the schools or in their surrounding communities' businesses. Wallace School District is an example of a district which has used the program to benefit the students, school and surrounding communities.

A cooperative agreement between Wallace and Mullan school districts and a local cable provider allows the students to run their own television station (Channel 3). The participating students gain valuable skills, which will serve them well in their adult lives as well as provide a needed service in their community.

Goal - Technology Systems Enhancing the Efficient Operation of Idaho Schools

Today's technology systems allow speedy, accurate access and storage of information, for decision making and reporting of student records to parents, school administration, and the State Department of Education. With the creation of efficient technology systems, Idaho's schools can function in an effective manner. The performance indicators chosen to measure efficiency include:

1) number of schools keeping track of student data electronically;
2) number of networked computers used for administrative purposes, and
3) number of districts submitting electronic reports to the State Department of Education.

Question - Have schools used technology to improve administrative efficiency in school operations?

Answer - Schools have used technology to improve administrative efficiency in school operations.

Cost - As reported by Idaho school districts, the amount of ICTL monies expended to achieve ICTL Goal 5, Technology Enhancing Efficient Operation of Schools; in the 1997-98 school year represents 39.48 % of the total ICTL dollars allocated.

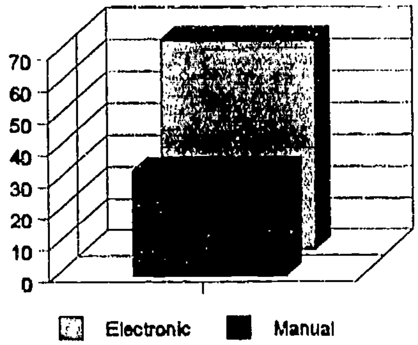
Evidence -

The number of networked computers in Idaho schools used for administrative purposes, was reported by building. According to QED, there are currently an average of 73 computers per district as well as 9.3 per district connected to the Internet (QED, 1998).

As seen below in Figures 12, 13, and 14, many school districts have migrated from manual systems of accounting for student data to an updated electronic media. Data from the 1997-98 ICTL Report reveals that of the 112 districts, 93% track student attendance electronically, 66% track discipline electronically, 63% track meals electronically, and 88% track grades electronically (ICTL, 1998).

000000001679

Fig. 12: Discipline Tracking



An additional benefit for Idaho's districts is the ability to submit reports online or in an electronic format. In the 1997-98 school year, 641 of 665 sites submitted accreditation information to the State Department of Education online. Moreover, 100% of school districts submitted enrollment count, attendance count, IBEDS, IFARMS and Special Education reports via diskette.

Fig. 13: Grade Tracking

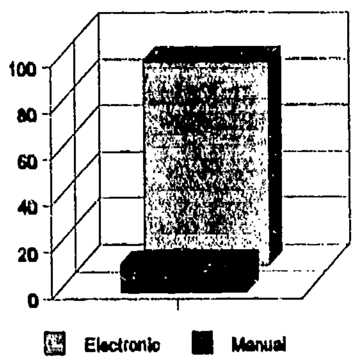
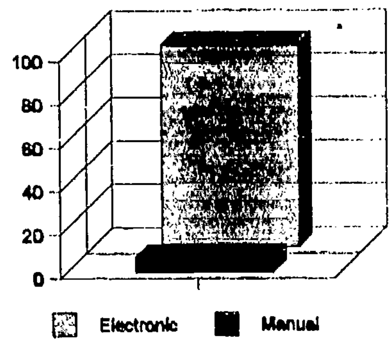


Fig. 14: Attendance Tracking



Descriptive Example-

An example of a technology system enhancing efficient school operation is the Kuna School District web site. Installed in 1997-98, the web site gives all students, administrators, and staff access to important information such as bus schedules, lunch schedules, yearly and monthly calendars, and extra-curricular schedules. Parents with Internet access can use the web site to find e-mail addresses for staff, find schedules for athletic events, and find specific information about their child's school. Teachers use the web site to find links to other educational resources, find information on professional development opportunities, and register for in-district technology classes. Some teachers have posted classroom information, such as class rules, policies, and daily homework assignments so both students and parents are kept up to date on classroom activities. High school science students take quizzes on-line, and receive immediate feedback on their answers. Examples of increased efficiency include: 1) reduced paper usage; 2) reduced number of parent telephone calls, and 3) quick dissemination of information to staff, parents, and students.

Goal - Training of Students to Maintain Technology

Over the past four years, school districts have been afforded and unprecedented opportunity to install, configure, and maintain technology systems. Allowing students to learn from this process, along side teachers and administrators, can be a cost efficient means of deploying and maintaining these technologies. Additionally, the experience provides students the opportunity to acquire a highly sought after skill set. The performance indicators chosen to measure the opportunity students have had to install, maintain, and support technology include:

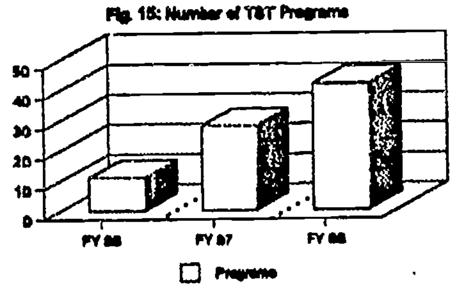
1) the number of Technology Student Technician (TST) programs in the State of Idaho, and
2) the number of enrollments in the TST programs.

Question - Are students able to install, maintain, and support technology?

Answer - Students have been given the opportunity to install, maintain, and support technology.

Cost - As reported by Idaho's school districts, the ICTL monies expended to achieve ICTL Goal 7, Student Training; in the 1997-98 school year represent 3.38% of the total ICTL dollars allocated.

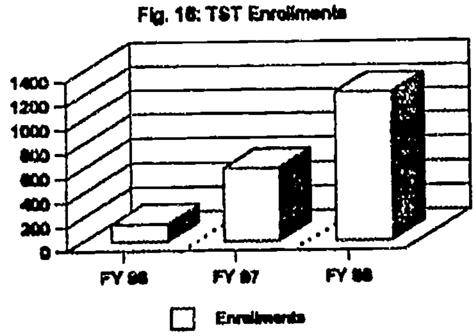
Fig. 15: Number of TST Programs



Evidence -

Currently, there are 42 TST programs in operation in Idaho's secondary schools, with an enrollment of 1,221 students. Recently, through a private grant program (The Technical Network for Training) has been set up to bolster the amount and quality of TST programs in Idaho's secondary schools.

Fig. 16: TST Enrollments



As seen in Figure 16, the number of TST programs has risen from 11 in 1996 to 42 in 1998, with a substantial increase in enrollment from 144 in 1996 to 1,221 in 1998.

Summary and Recommendations

This report clarifies issues surrounding the debate over whether the use of technology in Idaho's schools has had a positive impact on students. The benefits of technology in teaching and learning are clear: an increase in academic achievement in reading, mathematics, language and core studies, improved technology literacy, increased communication, well-trained, innovative teaching, positive relationships with the community, more efficient operation of schools, and technically qualified students ready to enter today's workforce

By appropriating funds, through the Idaho Technology Initiative, the legislature has made a valuable investment in Idaho's future which has paid and will continue to pay great dividends as shown in comparisons between Idaho and the Nation. Moreover, the funds distributed to districts, thus far have made it possible for Idaho schools to create a base upon which to build technology infrastructures such as hardware and software, compatible networks, timely teacher and student training, all which are key to providing for our students' needs in the 21st century.

It is important to note that schools, and local communities, as well as business and industry, have shown their support for the initiative by contributing monies for technology, extending the benefits of the initiative funds. However, to continue to experience these benefits, Idaho schools require continued support, not only from their communities and private sources, but from the state. Equipment must be upgraded and repaired to keep in step with industry standards. Teachers must continue training to be able to use the latest effective integration strategies in the classroom. Idaho's students deserve and require training on cutting-edge, state-of-the-art technologies to be able to compete with their counterparts in higher education as well as in the global marketplace.

Based on the gains shown in the first five years, it is recommended:

- The Idaho Legislature continue to fund the Idaho Technology Initiative for an additional five years.
- The Idaho Council for Technology in Learning (ICTL), continue to act as a governing body for Idaho school districts, by:
  - continuing to collect and report quantitative data on the benefit of technology for Idaho's students.
  - assisting districts to refine and expand the use of technology integration in the teaching and learning process.
  - maintaining school district and higher education accountability.
  - teacher training for integrating technology is of primary importance and should be funded appropriately.
  - providing state-of-the-art technology, meeting requirements of higher education and business.
  - training on-site technicians to support the infrastructure that is already in place.
- The Idaho Council for Technology in Learning (ICTL) and Regional Technology Outreach Programs are *adequately funded and staffed* to accomplish their goals and

objectives.

Recommendations for the ICTL:

- Continue to collect and analyze ITBS and TAP data in a longitudinal study.
- Ask school districts in advance to setup and run area specific local studies in cooperation with institutions of higher education.
- Standardize grant reporting formats for consistency.
- Determine what performance indicators need to be measured over the nest three to five years to promote consistency in data collection and reporting to the legislature.

Opportunities for the ICTL/Regional Technology Advisors:

- Provide adequate professional-technical training for school district network system administrators.
- Provide adequate training on integration of technology for school district teaching staff.
- Provide consulting services to districts regarding technology planning, and training.

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APPENDICES

Appendix 1: Summary of the Data Collection Model

SUMMARY

■ ICTL GOAL--INTEGRATION OF TECHNOLOGY

Performance Outcomes:
1. Students will improve their academic performance as a result of the integration of technology.
2. Students will improve their technological literacy as a result of exposure to technology.

Performance Indicators:	Data Source
• Tier 1-ITBS/TAP test scores	Riverside
• Tier 2-Regional university research studies	Regional Technology Advisors
• Tier 2-Student exposure to technology	Riverside
• Tier 3-Qualitative descriptions of integration	SDE-Technology Bureau

Procedure:

Tier 1

1. ICTL monies were made available in FY1995; therefore, we propose using the 1994-95 school year as a starting point by which to track student progress. Student progress can be demonstrated over time by comparing the ITBS scores of all students who were in the 4th grade in the 1994-95 school year and who will be taking the ITBS in the 1998-99 school year, and those who were in the 8th grade in the 1994-95 school year and will be taking the TAP in the 1998-99 school year.

2. Identify students "technology concentrators" who are taking the ITBS or TAP test in 1998 as either being exposed to a "technology rich" background or not by using a short survey prior to the exam.

3. Compare the academic gain scores among the groups showing academic improvement.

4. Compare percentage of high, medium and low technology concentrators to show exposure.

Note: More specific analysis could be accomplished in selected areas such as Math and English.

Tier 2

Identify Regional Studies that target and address specific academic performance outcomes. Aggregate and summarize results to show success of the performance outcome (integration of technology into the classroom).

Tier 3

Include qualitative data from grant proposals and technology plans which show integration of technology into the classroom curriculum.

Note: The data from the grant proposals will go out in Phase II after State Board approval in June. The reports are due from the districts November 1.

■ ICTL GOAL--COMPATIBILITY

Performance Outcome:
Schools will be able to share information and resources through technology.

Performance Indicators:	Data Source
• Tier 1-Number of LANs and WANs	QED 96-97 Q#13A
• Tier 1-Number of schools connected to the Internet	QED 96-97 Q#9
• Tier 1-Number of students using Internet	QED 96-97/Phase II
• Tier 1-Number of teachers using Internet	QED 96-97/Phase II
• Tier 1-Students participating in distance learning	SDVE/Phase II
• Tier 2-Descriptive examples of compatibility	SDE-Technology Bureau

Procedure:

Tier 1
Collect quantitative data on number of students using Internet, teachers using the Internet, students participating in distance learning, and student computers connected to a LAN. (Addition of a question on ITBS in October).

Tier 2
Glean descriptive information from ICTL grant proposals and reports that apply to the goal of compatibility.

- **ICTL GOAL--TEACHER PREPARATION:**

Performance Outcome:
Schools and Colleges of Education, working together, will effectively prepare instructors to teach using technology.

Performance Indicators:	Data Source
• Tier 1-Number of teachers taking assessments	Regional Technology Advisors
• Tier 1-Performance on the assessments	Regional Technology Advisors
• Tier 1-Extent to which in service training has been provided to teachers by school districts	Phase II
• Tier 1-Extent to which in service training has been provided to teachers (contact hours/number served)	Regional Technology Advisors
• Tier 2-Descriptive examples of teacher preparation	Regional Technology Advisors

Procedure:
Tier 1
Collection of data would be done through the Regional Technical Advisors (RTAs). Each RTA would submit a report containing pertinent data. The data would then be summarized and used in the final report to the legislature.

Data on district contact hours will be obtained via Phase II of ICTL Report.

Tier 2
Collection of the descriptive case would also be accomplished through the RTAs. Each RTA would submit a minimum of one study, with abstract, showcasing a relationship of successful teacher preparation practices or programs between the university and a school district.

Note: A question needs to be added to Phase II of the grant/report, "How many training contact hours has your district provided teachers in the last year?"

- **ICTL GOAL--COLLABORATION WITH COMMUNITIES AND BUSINESS**

Performance Outcome:
Schools will involve community members, business, and post-secondary institutions in the implementation and use of technology in the schools.

Performance Indicators:	Data Source
• Tier 1-"Other" dollars supporting technology	SDE-Technology Bureau
• Tier 1-Money generated locally through technology bonds, grants, donations	District Survey
• Tier 2-Description of collaborative projects	Regional Technology Advisors

Procedure:
Tier 1
Quantitative data on private dollars will be collected through SDE. Moneys accrued through technology bonds, grants and donations could be collected on Phase II of the grant report. Data on dollars spent per student could be used as an additional indicator.

Tier 2
96-97 grant report summaries of successful programs already submitted to ICTL could be utilized or an additional question could be added to Phase II of the ICTL report process requesting examples.

Note: Define "in-kind contribution" and develop a matrix for Phase II of the grant application ie: break out by federal, local bond and donated dollars.

■ ICTL GOAL--TECHNOLOGY SYSTEMS ENHANCING EFFICIENT OPERATION OF THE SCHOOLS

Performance outcome:
Schools will use technology to improve administrative efficiency in schools operations.

Performance Indicators:	Data Source
• Tier 1-Number of schools keeping track of students electronically (grades, lunch, discipline, attendance)	District Survey
• Tier 1-Number of networked computers used for administrative purposes.	QED 96-97 Q# 1C
• Tier 1-Number of schools submitting electronic reports to SDE i.e. IBEDS, School Accreditation.	SDE-Technology Bureau

Procedure:
Tier 1
QED data could be utilized to report the number of networked computers as well as number of computers used for administration as of 1996-97.
Note: An addition to ICTL Phase II report could help acquire data on number of school districts who keep electronic student records.

■ ICTL GOAL--TRAINING STUDENTS TO MAINTAIN TECHNOLOGY

Performance outcome:
Students will be able to install, maintain and support technology.

Performance Indicators:	Data Source
• Tier 1-Number of Technology Support Technician (TST) programs operating	State Division of Vocational Education (SDVE)
• Tier 1-Student enrollment in TST programs (growth in enrollment)	SDVE

Procedure:
Tier 1
TST data can be utilized to show how the districts have been training students to help maintain, install and support technology. The number of programs as well as student enrollment in TST programs between 1994 and 1998 would provide data on change in student involvement over time. SDVE currently has the data needed. A summary will be provided.

Appendix 2: Data Collection Matrix

Data Collection Matrix Data Item	Source Phase II	OED	ITBS	RTA	SDE	SDVE	Indicator	Tier
Student exposure to technology			X				1	1
Student technology literacy			X				1	1
Increase in ITBS/TAP scores			X				1	1
Regional University research studies				X			1	2
Descriptive examples of integration					X		1	3
Number of students using the Internet	X						2	1
Number of local and wide area networks		X					2	1
Number of schools connected to the Internet		X					2	1
Students participating in distance learning/Dual Enroll	X						2	1
Students participating in distance learning/H.S. to H.S.	X						2	1
Number of teachers using Internet	X						2	1
Descriptive examples of compatibility					X		2	2
Number of University/District inservice contact hours				X			3	1
District contact hours technology inservice training	X						3	1
Number of teachers taking the assessments					X		3	1
Number of teachers passing assessments					X		3	1
Descriptive examples of teacher inservice				X			3	2
District in-kind contributions	X						4	1
Number of schools who passed technology bonds	X						4	1
Descriptive examples of collaboration					X		4	2
Number of schools tracking students electronically	X						5	1
Number of computers used for administrative purposes		X					5	1
Number of districts submitting electronic reports to SDE					X		5	1
Student growth in TST programs						X	6	1
Number of times teachers used email	X						2	1
Number of times students used email	X						2	1
Number of TST programs						X	6	1

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Appendix 3: IFARMS Technology Expenditure Master

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IFARMS TECHNOLOGY EXPENDITURE ADDENDUM MASTER
FORM B
FY 1997-98
FUND 245

IFARMS Category/ICTL Goal	Totals
100 Salaries	
Goal 1 - Integration	$172,990.87
Goal 2 - Compatibility	$94,844.26
Goal 3 - Collaboration w/ Colleges	$92,140.61
Goal 4 - Collaboration w/ Community	$30,307.47
Goal 5 - Technology Systems	$224,633.61
Goal 6 - Evaluation	$36,234.33
Goal 7 - Student Training	$106,884.19
Goal 8 - Systems Support	$427,829.91
Total 100 Salary	$1,185,865.25
200 Benefits	
Goal 1 - Integration	$26,614.47
Goal 2 - Compatibility	$22,359.86
Goal 3 - Collaboration w/ Colleges	$20,274.08
Goal 4 - Collaboration w/ Community	$5,896.50
Goal 5 - Technology Systems	$36,838.60
Goal 6 - Evaluation	$7,762.23
Goal 7 - Student Training	$23,376.72
Goal 8 - Systems Support	$70,805.47
Total 200 Benefits	$213,927.93
300 Purchased Services	
Goal 1 - Integration	$229,975.16
Goal 2 - Compatibility	$161,745.44
Goal 3 - Collaboration w/ Colleges	$149,333.83
Goal 4 - Collaboration w/ Community	$29,454.69
Goal 5 - Technology Systems	$330,709.25
Goal 6 - Evaluation	$17,195.55
Goal 7 - Student Training	$19,231.78
Goal 8 - Systems Support	$289,655.24
Total 300 Purchased Services	$1,227,300.94
400 Supplies and Materials	
Goal 1 - Integration	$387,663.32
Goal 2 - Compatibility	$164,725.64
Goal 3 - Collaboration w/ Colleges	$21,128.68
Goal 4 - Collaboration w/ Community	$24,613.93
Goal 5 - Technology Systems	$550,320.95
Goal 6 - Evaluation	$21,563.95
Goal 7 - Student Training	$62,651.23
Goal 8 - Systems Support	$228,979.74
Total 400 Supplies and Materials	$1,461,647.44
500 Capital Objects	
Goal 1 - Integration	$2,823,551.67
Goal 2 - Compatibility	$954,455.70
Goal 3 - Collaboration w/ Colleges	$60,387.21
Goal 4 - Collaboration w/ Community	$121,820.45
Goal 5 - Technology Systems	$1,599,275.48
Goal 6 - Evaluation	$61,537.88
Goal 7 - Student Training	$126,602.49
Goal 8 - Systems Support	$204,202.72
Total 500 Capital Objects	$5,952,033.60
District Totals	$10,040,775.16

ICTL Dollars Spent on Each Goal

Goal	Total $	% of $
1	$3,640,795.49	36.26%
2	$1,398,130.90	13.92%
3	$343,264.41	3.42%
4	$212,093.04	2.11%
5	$2,741,777.69	27.31%
6	$144,293.94	1.44%
7	$338,946.41	3.38%
8	$1,221,473.08	12.17%
*	$10,040,775.16	100.00%

* Figures Reflect 108 of 112 Districts Reporting

Appendix 4: Technology Exposure Questionnaire

Technology Exposure Survey

Directions: Listed below are questions which are designed to measure the amount of exposure you have had to technology over the past four years. Please read each question carefully, then mark the response box that best describes your experience on the test answer sheet in the student ID number box. Then write the answer you chose in the empty box below the number of the question in the student ID number box. This is ***NOT*** a test so there are no right or wrong answers; all answers will be kept confidential.

Example:

How much opportunity have you had over the past four years to write stories using the computer?

0 = A lot 1= Some 2 = Not Very Much 3 = Almost None

The student in this example felt that she had a lot of opportunity over the past four years to write stories on the computer for class assignments, so she filled in the response "0" on her test answer sheet. Then she wrote the answer "0" in the empty box below the question in the student ID number box.

---

1. How capable are you at choosing the appropriate tool for completing a project; for example, using a word processor for a report or software like PowerPoint or Hyperstudio for a class or group presentation?

   0 = Very Capable 1= Somewhat Capable 2 = Not Very Capable 3 = Poor

2. Over the past four years, the teachers in my school have discussed legal, ethical, and acceptable uses of computers in our classroom.

   0 = A lot 1= Some 2 = Not Very Much 3 = Almost None

3. How much opportunity have you had over the past four years to design, develop, or present class projects using technology (i.e. web pages, video, presentation software, etc.)?

   0 = A lot 1= Some 2 = Not Very Much 3 = Almost None

4. Over the past four years, how much have your teachers discussed with you the advantages and disadvantages of relying on technology for completing classroom assignments?

   0 = A lot 1= Some 2 = Not Very Much 3 = Almost None

5. How capable are you using computer software to simulate real-world situations such as taking a historic journey back in time, building a city, or investing in the stock market?

   0 = Very Capable 1= Somewhat Capable 2 = Not Very Capable 3 = Poor

6. How much opportunity have you had over the past four years to work with other students using technology to contribute to a project?

   0 = A lot 1= Some 2 = Not Very Much 3 = Almost None

7. How much opportunity have you had over the past four years to identify and solve routine problems (troubleshooting) related to making a computer work?

   0 = A lot 1= Some 2 = Not Very Much 3 = Almost None

Over Please ☺

8. How capable are you at using e-mail and Internet to help complete classroom assignments and projects?

0 = Very Capable 1= Somewhat Capable 2 = Not Very Capable 3 = Poor

9. Over the past four years, on average, I use the computer at home _____ per week?

0 = 8 or more hours 1 = 4 to 7 hours 2 = 1 to 3 hours 3 = 0 hours

10. Over the past four years, on average, I use the computers at school _____ per week?

0 = 8 or more hours 1 = 4 to 7 hours 2 = 1 to 3 hours 3 = 0 hours

Appendix 5: Additional Example Summaries of Higher Education Research

"Completed" Studies/Projects

Boise State University

Effects of Technology and Curriculum Integration on 3rd Grade Students' Technology, Thinking, and Science Process Skills

Third grade students, of mixed ability, were used to evaluate technology skill development. Pre and posttests were conducted prior to and immediately after instruction. Following their project research, students developed database, spreadsheet, and word processing documents. Collective data was extensive in all areas of the study. Conclusions revealed that all students, through the use of technology, showed measurable improvement in self-efficacy and objective knowledge. In addition, all classes showed significant growth in applied descriptive vocabulary.

A Comparative Study of Geometry Achievement using Geometer's Sketchpad

The study attempted to demonstrate that students using specific software gained a greater understanding of geometric principles than those students who do not use the program. Two sections of a geometry class used Geometer's Sketchpad while two sections did not use the program. The same teacher taught all sections and the achievement of both sections was compared. While a significant difference was noted between groups, it was concluded that there was no appreciable interaction among the achievement levels. This indicated that levels remained constant between the instruction methodology.

Vallivue High School PLATO Pilot Research Project

This study, using at-risk students, attempted to demonstrate increased achievement in content area courses using the PLATO system compared to progress in traditional classes. Pre and posttest data was collected over a year's time and measured for gain in three categories (Reading for Understanding, Sentences, and Envelope Writing). Sixty-four percent of the students participating in the study showed measurable gains in all three areas.

Does the Use of Hypermedia Software Affect the Learning of 6th Grade Social Studies Students?

This study was designed to investigate the effectiveness of computers in improving test scores, time-on-task efficiency, and content retention. Data collection involved forty-six students, divided into a control group and experimental group. Two instructional units over a period of five weeks. Students in the experimental group used "Hyperstudio" to access information and to create a report. Pre and posttest results indicated a marked improvement in daily worksheet grades for the experimental group. However, no significant difference was measured on chapter and unit pre and posttest scores.

University of Idaho (Moscow)

Investigating the Use of the Internet as an Alternative Instructional Delivery Mode

A total of fifty-one students, in three groups, were used in the study. Pre and posttest data was collected from all groups that received the same amount and quality of instruction for all modules. Statistical analysis indicated no significance between the groups. However, this is considered to be a positive result as it suggests that the Internet group performed as well as the other groups. The inference being that, carefully developed and implemented, the internet is a viable, alternative instructional delivery mode.

Investigating the Use of Microcomputers as Enhancement Aids to Facilitate Lessons by Teachers

Experimental and control groups involving fifty-three elementary students participated in the study. Similar instruction was delivered to both groups. Following the instruction, depending upon the groups, students were then allowed to use either the computer with appropriate software or traditional worksheets and workbook activities as enhancement aids. The Iowa Test of Basic Skills (ITBS) was used to gather pre and posttest data. Statistical analysis favored computers as effective enhancement aids suggesting that computers assist student learning as related to the content areas of mathematics and language arts.

"In Progress" Studies/Projects

Boise State University

Vallivue High School PLATO Research Project

Using a class of special needs and traditional students, the PLATO system will be utilized to assess the effectiveness of a computer program in meeting the needs of students assigned to or requesting the Resource Room. The study will focus on whether at-risk and traditional students using the PLATO system and appropriate software demonstrate increased achievement in content areas as compared with traditional teaching methodology.

Patterns of Technology Access

The aim of this study is to identify distribution patterns of technology for special needs students compared to normally achieving students, and examine how these patterns and arrangements may affect student outcomes and accessibility for all students. This takes into account such students with disabilities and those with limited English speaking proficiency. Collected data will include specially prepared surveys from students, teachers, and district personnel.

Technology Based Writing Partnerships Between 6th and 12th Grades and 8th and 11th Grades

Telecommunications (e-mail) is the basis for this study. Students using e-mail will be compared with students not using e-mail to determine if writing skills will show a measurable difference over a given period of time. Writing partnerships will be formed between 6th and 12th grade students and 8th and 11th grade students. In addition to pre and posttests for assessments, each student will be required to complete an electronic writing portfolio. Data comparing previous non-technology based communications will be evaluated along with an assessment of changes in writing grade levels.

Database & Science: Integrating Databases into the 5th Grade Science Curriculum

This study employs ten 5th grade teachers in the Meridian School District. The experimental group consists of five classrooms with access to computers. The control group will not use computers. The content and objectives of the unit are based upon the current science textbook and the focus of the study is to measure differences in science learning. Pre and posttest assessment will be chapter and unit tests from the assigned science textbook.

Do Students Who Have Access to Word Processors Learn Compositional Writing Skills Better Than Students Who Use Manual Writing Process Techniques?

Two groups (A&B) will be used to investigate student achievement and efficiency in compositional writing. Experimental Group A will use word processing software to complete all phases of a student writing assignment. Control Group B will carry out the same assignment using paper and writing instruments. Note taking, first drafts, and final papers, along with the 8th grade writing competency exam scores will be used as dependent measures for comparison.

Do 11th and 12th Grade Students Doing Research, Note Taking, and Technical Writing Experience Better Achievement Using AlphaSmart Portable Word Processors than Manual Techniques?

The purpose of this study is to Investigate the uses of technical writing aides in comparison to manual techniques in helping students achieve at higher levels. Writing classes will be divided into two groups (A&B). The experimental group (Group A) will use AlphaSmart portable word processors while Group B will complete the same assignment using paper and writing instruments. All materials will be collected and analyzed along with time-on-task observations for dependent measures in comparison.

Do Sixth Graders' Show Greater Technology Competency Acquisition Gains when Computers are placed in a Classroom or in a Laboratory?

Technology instruction either: a) integrated into the classroom curriculum with computers in the classroom; or, b) throughout direct instruction of technology curriculum in a computer lab will be used to determine the impact on 6th graders' computer competency. Criterion-referenced technology competency exam scores will compare student technology achievement. Student satisfaction surveys and observations of time-on-task will also assess productivity and efficiency.

University of Idaho (Moscow)

Investigating the Effect of Hypermedia on 4th Grade Student Achievement in Mathematics

A design is being implemented to use a group of students who were taught without the benefit of Hypermedia software. A new group will be taught the same content with the addition of specific Hypermedia software to enhance instruction. Following instruction, students will be assessed using pre and posttests to determine if there is a significance difference between students using Hypermedia to enhance mathematics instruction and students who do not.

To What Extent Does the Technology Enhanced Classroom Impact Student Achievement in Language Arts?

An experimental design using traditional control/experimental groups will be used to compare student achievement. Groups will receive different instruction and/or have access to specific technology and software. The groups will be evaluated using the State Direct Writing Assessment to determine achievement.

Idaho State University

Does teacher training, in a specific mathematical problem solving software positively impact the acquisition of mathematical problem-solving skills at the upper elementary level?

Teachers were trained during day-long, hands-on workshops with the specific software. They were required to design a lesson incorporating the software into their mathematics curriculum, teach the lesson, and then report the results. Thus far, reported results are anecdotal and positive. Pretesting is currently underway to collect quantitative results from 26 classrooms using the program.

Will training in a specific geography software program positively impact the acquisition of geography-related concepts in the secondary classroom?

Teachers were trained during day-long, hands-on workshops with the specific software. Teachers were required to design a lesson incorporating the software into an appropriate area of their curriculum, teach the lesson, and then report the results. Teachers anecdotal reports show that student interest ranged from "mildly interested" to "actively interested and engaged". Pretesting is underway to collect quantitative data from 35 secondary teachers using the program.

What changes occur in teacher knowledge, attitude, and implementation of technology as a result of specific multi-media training?

Through the Just-in-Time Technology Challenge Grant, teachers were given specific training in incorporating multi-media software into classroom instruction. Approximately 240 teachers were selected to take part in the first year of the project, and were involved in a four-day training session. Pre-test information has been collected on teacher attitudes, technology use, and self-assessment. Student training and project development begins in January of 1999.

Appendix 6: Additional Examples of School District Research

SCHOOL DISTRICT PROJECT SUMMARIES

Boise School District #1

- Using the Waterford Early Reading Program, two schools and 155 students were involved in a study designed to evaluate the impact of specific software on the learning process. A control group and experimental group were used and pre/posttests were administered. The results indicated that the experimental group (using Waterford Early Reading Program) outperformed the control group by a significant margin.

Glenn's Ferry School District #192

- Two classes of advanced anatomy students were used in a study to see if appreciable gains would occur in academic performance with one class using laptop computers and the other class being taught in a traditional manner. In addition to increased academic performance demonstrated by the class using computers, it was also noted that there were improvements in time-on-task, motivation, and attendance. Students using computers were also required to make a multi-media presentation as part of the class requirement.

Valley School District #262

- Computers were used with mentally challenged students working on multiplication tables. Previously, these students were unmotivated by traditional techniques and displayed little progress over a period of one and a half years. Given computers and appropriate software there were noted differences in motivation. Students appeared to enjoy what they were doing and demonstrated increased motivation and positive attitudes. Learning increased significantly as evidenced by average pretest scores of 72% compared to average posttest scores of 89%.

Emmett School District #221

- This study focused on a self-confidence survey administered to all teachers. Based on the individual results, each teacher was able to diagnose and prescribe a professional development plan for technology. Classes, seminars, and work sessions dealing with computer skills and integration were generated. The emphasis on training and individual study resulted in improved confidence and increased computer literacy.

Clark County School District #161

- A district-wide assessment was conducted to determine student (K-12) learning preferences with computers as a given choice. Teachers were also surveyed to determine to what degree and level of usage computers were integrated in the classroom. Both students and teachers indicated positive attitudes in the use of technology and a majority of students chose computers over other forms of learning. Using classroom observations, teachers determined that students strengthened, improved, and reinforced skills through the use of the computers.

Firth School District #59

- A study was conducted to determine if certificated district personnel after using computer technology and software has shown significant improved technology competency. Measurement was conducted through the use of a pre/posttest on computer literacy and skills. Six classes in tech training, access to Internet, telecommunications (e-mail) were offered district staff and teachers. Following the training, knowledge and skill levels increased by 30%.

Blackfoot School District #55

- This study involved twenty-one principals from rural districts. The purpose of the project was to show how attitudes and personality types influenced implementation of technology by school administration. Principals received training in the use and integration of computers. A pre/posttest was administered. It was determined that there was no significant correlation between attitudes and training. However, principals did maintain a positive attitude toward the implementation of technology. Also expressed was the opinion that technology training for teachers is inadequate.

Hansen School District #415

- Using specific software (SkillsBank, Accelerated Reader), grade level trends were monitored using ITBS and TAP scores to determine gains in the areas of math, language arts, and reading. While the study is still in progress, initial results indicate that grade levels using SkillsBank (math, language arts) showed the most gains in their ITBS scores. Because Accelerated Reader was recently adopted, it has not been evaluated for significant improvements in standardized test scores.

"IN PROGRESS SUMMARY"
SCHOOL DISTRICT REPORTS

Several school districts submitted reports of studies that were still in progress. They reflected a range of creativity and resourcefulness in measuring the benefit that the integration of computer technology and software has on student performance in the classroom.

The extent of these on going studies includes a cross section of elementary, middle school, and secondary grade levels. The expanse of curriculum reported under study involves language arts, reading, science, business, and technical writing. A focus of in-progress studies also includes comparative data on basic skills as they relate to ITBS test scores tracked over a four-year period, evaluation of technology competency acquisition, a correlation of technology integration with grade performance, attendance, and discipline, and teacher attitudes.

Appendix 7: Glossary of Terms

Glossary

Core Battery - a subset of 7 to 9 tests which are included in the Complete Battery. For level 5-8 the Core includes tests on vocabulary, word analysis, reading, listening, language, math concepts, and math problems. For the level 9-14 the Core includes tests on vocabulary, spelling, capitalization, punctuation, usage and expression, math concepts and estimation, math problems, and math computation.

Effect Size - the degree to which the effect is present in the population. I.e how many standard deviations separate the effect means.

Standard Score - the Developmental Standard Score is a number which describes a student's location on an achievement continuum. The main advantage to using the Standard Score instead of the Grade Equivalent Score is that it better mirrors reality. I.e. the Grade Equivalent Score shows an equal average growth between any pair of grades.

Gain Score - the difference between the Standard Scores of two data points.

Projects

West Virginia Study

Under what conditions is technology effective in advancing learning and teaching?
This is the fundamental question that drives the research of the Milken Exchange on Education Technology.

Education technology evolves quickly because of changes in technology and advances in our understanding of how to use it, engage, challenge and nurture learners. The lag between the introduction of a program and evidence of its effectiveness may be significant. Still, it is useful to know what kinds of education technology work and in what ways.

This study of West Virginia's Basic Skills/Computer Education is a collaborative investigation by the **West Virginia Department of Education**, the educators and students in the schools studied, the Milken Family Foundation, and Interactive Inc.

The findings suggest that Virginia's Basic Skills/Computer Education program has had a positive impact on learning. West Virginia has had across-the-board increases in statewide assessment scores in all basic skills areas, and their NAEP (National Assessment of Educational Progress) scores have gone up. (Please download a copy of the report to see where gains were noted and how technology was integrated into the curriculum.)

The West Virginia Story's authors:

Dr. Dale Mann, a professor at Teachers College, Columbia University and founding chair of the International Congress for School Effectiveness, an organization with members from more than half the countries of the world that is dedicated to improving schooling for the neediest children;

Dr. Charol Shakeshaft, a professor at Hofstra University. She is a specialist in research methods and a pioneer in the field of gender equity and schooling. Dr. Shakeshaft is the author of a leading textbook on women in educational leadership.

Jonathan Becker, J.D. is a research specialist in law and education. A doctoral student at Teachers College, Columbia University, he is interested in social science research utilization in the educational policy context.

Dr. Robert Kottkamp is a professor in the Department of

Administration and Policy Studies at Hofstra University where he teaches research methods, administrative leadership and reflective practice.

Publications
3/10/99

West Virginia Story

by Dale Mann, Ph.D., Charol Shakeshaft, Ph.D., Jonathan Becker, J.D., Robert Kottkamp, Ph.D.

This study examines West Virginia's long-running Basic Skills/Computer Education program and its positive impact on students' standardized test scores.

Articles
3/10/99

West Virginia Study Results

Exchange study finds direct link between use of learning technology and higher academic achievement in West Virginia. Students raised their standardized test scores in math, reading and language arts since the state implemented its Basic Skills/Computer Education Program.

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WEST VIRGINIA STORY:

Achievement gains from a statewide comprehensive instructional technology program

Dale Mann, Ph.D.
Charol Shakeshaft, Ph.D.
Jonathan Becker, J.D.
Robert Kottkamp, Ph.D.

Afterword by
Lewis C. Solmon

Preface

Under what conditions is technology effective in advancing learning and teaching is the fundamental question that drives the research interests of the Milken Exchange on Education Technology. The West Virginia Basic Skills/Computer Education (BS/CE) technology implementation beginning nearly ten years ago deserves our scrutiny because of its scale, consistency and focus. What can we learn from an approach that spanned a whole state for a full decade? The issues of system design, training, technology capacity, technical support, and means of measurement are all powerfully present in the West Virginia experience. The goal of the Exchange in commissioning the study was not to praise it or criticize it, but to understand it and to make that understanding known to others.

The findings of this study suggest strongly that the BS/CE program had a powerfully positive effect in West Virginia, especially in those schools that used it most intensively.

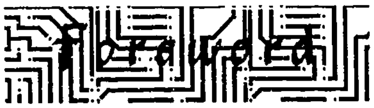
- Significant gains in reading, writing, and math were achieved.
- BS/CE was found to be more cost-effective than other popular interventions including class-size reduction.
- The program was especially successful with low income and rural students as well as with girls.

But these findings need to be interpreted cautiously by educators and policymakers because:

- BS/CE is based on instructional learning systems designed over a decade ago and limited to the then available technology. For example, easy access to the Internet was just a dream in 1989.
- The pedagogy upon which instructional learning systems are based makes little use of project-based learning and other constructivist curricular approaches that are the leading edge of learning technology today.
- BS/CE fit the learning and teaching realities of West Virginia over the last decade. That does not make it appropriate for every district or state where the characteristics of learners and teachers may be quite different.

Learning technology evolves quickly because of changes in technology and advances in our understanding of how to use it to engage, challenge and nurture learners. The lag between the introduction of a program and evidence of its effectiveness may be significant. Still, it is useful to know what works and in what ways. The future forms of learning technology are impossible to predict, but we can design them better based on the islands of research that help explain where we have been.

Cheryl Lemke
Executive Director
Milken Exchange on Education Technology



The West Virginia Department of Education is pleased to collaborate with the Milken Family Foundation in the publication of a landmark study documenting the powerful and positive impact of the Basic Skills/Computer Education program on student achievement in West Virginia.

Our experience and data tell us that the Basic Skills/Computer Education program is successful. West Virginia has had across-the-board increases in statewide assessment scores in all basic skills areas, and our NAEP scores have improved. Just as importantly, we have seen the faces of children light with excitement and learning and have heard the renewed enthusiasm of teachers when technology is integrated into the curriculum.

The reasons for West Virginia's success are numerous. Clearly articulated goals focus upon increased student achievement in reading, mathematics, and composition. Software was aligned with the West Virginia Instructional Goals and Objectives. Implementation, which began in the earliest grades, moves upward each year. Comprehensive and timely staff development enables teachers to correlate the software with the curriculum and integrate the technology into instruction. The state-purchased computer systems are distributed equitably and provide a consistent platform for instructional and support purposes. Administrative support at the county, region, and state board of education levels provides clear evidence of program importance. All of these factors were developed through participating stakeholders who provided a bottom-up approach that created a statewide solution for technology integration.

West Virginia's model calls for increasingly higher standards for student achievement. As our model continues to be buttressed by implementation of best practices identified in solid research, West Virginia students will progress to meet these higher standards. This study adds to the limited body of solid research on the impact of learning technologies on student achievement.

The Milken Family Foundation is to be commended for promoting research aimed at identifying those factors that contribute to student achievement with the use of learning technologies. This study is a collaboration among the West Virginia Department of Education, the educators and students in the schools studied, the Milken Family Foundation, and Interactive, Inc. This collaborative effort is truly appreciated. Increasing student achievement remains our central focus, and the effective implementation of technology will continue to advance this goal.

Henry R. Marockie
State Superintendent of Schools
West Virginia

TABLE OF CONTENTS

List of Tables

List of Figures

WEST VIRGINIA STORY:

Achievement gains from a statewide comprehensive instructional technology program

EXECUTIVE SUMMARY

The Program.

West Virginia's "Basic Skills/Computer Education" program is unique in its eight year longevity and in its documented student achievement outcomes. This report describes the program and connects its features to gains in student test scores that are practically and statistically significant.

The Basic Skills/Computer Education (BS/CE) program was authorized in 1989-90 and, beginning with the kindergarten class of 1990-91, hardware and software were installed in schools and teacher training began. The program consists of three basic components:

(1) software that focuses on the State's basic skills goals in reading, language arts and mathematics;

(2) enough computers in the schools so that all students will be able to have easy and regular access to the basic skills software; and

(3) professional development for teachers in the use of the software and the use of computers in general.

Each year from 1990-91 onward and beginning with kindergarten, at a cost of about $7 million per year, the State of West Virginia provided every elementary school with enough equipment so that each classroom serving the grade cohort of children targeted that year might have three or four computers, a printer and a school-wide, networked file server. Schools could choose to deploy the computers in labs and centers or distribute them directly to classrooms. As the 1990-91 kindergarten class went up the grades, so did the successive waves of new computer installations coupled with intensive professional development for teachers and software chosen from either IBM or Jostens Learning.

Research Methods.

We collected data from all fifth graders (950) in 18 elementary schools that were selected to represent the range of variables that might influence technology use and student achievement, e.g., intensivity of BS/CE use, software vendor, student prior achievement and sociodemography. The 1996-97 fifth graders had the most complete test score records and they were the first cohort to have had the consistent availability of BS/CE across their entire school experience. The sample size supports generalization at the 95% level of statistical confidence. We collected survey data from 290 teachers in the study schools. Data were both quantitative (state and publisher's test files, survey results) and qualitative (on-site field documentation, case analysis, interview results).

Student test data were scaled scores on the Stanford-9 achievement test. Because scaled scores are normed against a nationally representative group, they are appropriate for comparison purposes and for the computation of gain scores. Our emphasis is on gains in "basic skills," a score computed and reported by the West Virginia Department of Education for comparison purposes, and a score that measures the math, reading and language arts areas that were the focus of BS/CE.

Explaining Test Score Variation: The Access/Attitude/Training Model.

We used factor analysis to search for input phenomena that were grouped both conceptually and in terms of respondent perceptions and that were also related to variation in student test scores. The three components of this empirically-derived model—access, attitude, and training—are similar to what leaders in instructional technology advocate. Unless there is sufficient equipment and opportunity to learn (access) there are unlikely to be effects from instructional technology. And, unless teachers have a chance to learn about the technology and how it may make them and their students more successful (training), they are less likely to believe it can help (attitude) and, in fact, to use it.

BS/CE Effect on Student Achievement.

The more of each of the model components that the student experienced, the higher the gain score on the Stanford-9. The BS/CE technology regression model accounts for 11% of the total variance in the basic skills achievement gain scores of the 5th-grade students. That impact is powerful and practically significant; it is also statistically significant at more than the .001 level. More to the point, an 11% improvement in test scores would be welcomed by most students, parents and educators.

But, we believe that the 11% explained by our model underestimates the value added by instructional technology. First, schools are only one of several educators. Family background explains a great deal about why some children do better than others. Since James Coleman's 1965 research, we have known that children's achievement in school is conditioned more by what they bring to school than by what schools are able to do with them. Consider:

> (D)espite the wide range of diversity of school facilities, curriculum and teachers, and despite the wide diversity among student bodies in different schools, over 70% of the variation in achievement for each group is variation within the same student body (James S. Coleman, et al, *Equality of Educational Opportunity.* Washington DC., US Department of Health, Education and Welfare, 1966, p. 77).

If, as Coleman and others assert, 70% of the variation in test score performance relates to family and other home and background factors, that leaves 30% that schools can influence. We call that 30%, "school accessible performance."

This analysis documents that as much as 11% of the gain score variance for one year can be explained by BS/CE. Thus, BS/CE explains more than a third of the "school" reasons why students' achievement scores improved. Said another way, of all the factors that can affect a child's learning, about 30% is within the school's sphere of influence. The BS/CE technology initiative explained nearly 11% of that 30%.

There are two additional reasons to believe that the reported gain scores underestimate the total effect of BS/CE. The 11% represents gain score variation explained by BS/CE within a single year, i.e., 1997 to 1998. However, these fifth graders had BS/CE for four previous years. Thus, the cumulative effect of BS/CE most likely accounts for more than the 11% of the single year gains that we found.

We also suspect that the gain scores reported are unnecessarily conservative because current hardware and software is more powerful than what was implemented in BS/CE's early years. Current technology is likely to yield even larger gains.

The Distribution of Achievement Gains Across Groups of Children.

BS/CE helped all children perform better, but the data indicate that BS/CE helped the neediest children the most. Those children without computers at home made the biggest gains in (1) total basic skills, (2) total language, (3) language expression, (4) total reading, (5) reading comprehension, and (6) vocabulary. Also, the Access/Attitude/Training model explains more of the basic skills gain scores for students who report lower grades.

Although the relative disadvantage of girls is a regularity of the technology and the gender literatures, girls and boys reported the same access and the same use of computers in West Virginia. The more years that girls report having used computers, the more they like them and the more they report knowing about them. (Students reported increased computer use every year from kindergarten through the fourth grade.) Girls reported that computers were more accessible to their particular learning needs than were their teachers. In math and reading outcomes, there were no gender differences.

Teachers and BS/CE.

More than half the State's teachers are confident in using computers in their teaching, only 19% are not. Half the teachers thought that technology had helped "a lot with West Virginia instructional goals and objectives." Almost half the teachers became more enthusiastic about BS/CE as time passed.

Implementing BS/CE.

BS/CE was fielded as it was designed—with a critical mass of hardware, software and training tightly focused on a grade-by-grade follow through schedule and on basic skills acquisition.

Schools could choose how to deploy the BS/CE computers—concentrated in labs, distributed to classrooms or a combination of lab-plus-classroom distributed. The deployment choice reflects compliance with the current goal of "technology integration into classrooms," and is thus significant for policy and crucial to teachers.

Students who had access to BS/CE computers in their classrooms (the "distributed" pattern) did significantly better than students who were taught with BS/CE equipment in lab settings. They had higher gains in overall scores and in math. They also scored higher on the 1998 tests than did those in labs. (There were no differences on scores by source of software.)

Teachers who had computers in the classroom reported higher skill levels in delivering instruction, planning lessons, managing paperwork and word processing. Teachers who had BS/CE computers in their classrooms also reported more time using BS/CE computers for reading, math and writing instruction than either of the other two patterns. Sixty-one percent of the teachers with access to computers in their own classrooms said they were confident in using computers in their teaching compared to only 43 percent of the teachers who took their children to a lab for instruction in, about, or with computers.

Additional Explanations for Test Score Gains.

During the period studied, the State renovated 470 schools and built 68 new buildings. Between 1990 and 1993, increases to the average teacher's salary moved West Virginia up from 49th to 34th among the states. Still 48% of the teachers chose "technology" as the number one explanation for student learning gains.

The state also required or instituted "Unified School Improvement Planning," a statewide curriculum framework ("West Virginia Instructional Goals and Objectives"), local school councils, faculty senates, school site accreditation visits and a "probationary" procedure. Also during this period, West Virginia Bell connected 700 of the State's 840 school buildings to Bell Atlantic's "World School" Internet service. The measured presence of "other technology related initiatives" accounts for 0.4% of the variance in achievement scores. Each of those initiatives probably accounts for parts of the total improvement although it was beyond the scope of this analysis to establish those amounts.

Conclusions.

This analysis establishes how much value can be added on a statewide basis from a sustained instructional technology initiative. The data indicate that as much as a third of the gains in "school accessible achievement" can be powered by instructional technology. The data also signal aspects of policy strategy and tactics.

BS/CE is scalable. The expenditure proportions are not beyond reach for other states. (See also Lewis Solmon's "Afterword.") The outcomes are established. The program's components have been well documented.

As other jurisdictions consider instructional technology as an agent of improvement, is it of interest that a package of hardware/software/process innovations can account for a large fraction of the test score improvement that is available to public policy intervention? And is it of further interest that, in addition to test score gains, those innovations can help position children for a technologically demanding economy, society and polity?

BS/CE also has a number of features that are uncommon in the state education policy landscape. The features that deliver an installed base critical mass depart from the norm of a small number of computers equitably distributed across a large number of classrooms. The choice of software from a fixed set of two vendors departs from the conventional ceding of choice among hundreds of vendors to hundreds of schools (and often, to thousands of teachers). We believe that part of the explanation for BS/CE's success is the defined focus of its implementation.

Still, policy choices, political choices always honor local values. In American schooling, thousands of jurisdictions make their own choices. It may be that this documentation of the student outcomes associated with West Virginia's program of Basic Skills/Computer Education will advance the consideration of similar initiatives in other jurisdictions.

WEST VIRGINIA STORY:

Achievement gains from a statewide comprehensive instructional technology program

1.0 INTRODUCTION

West Virginia's instructional technology initiative is unique in its eight year longevity and in its documented student achievement outcomes. This report describes the results of quantitative and qualitative analyses conducted with the support of the Milken Exchange on Education Technology across a stratified sample of schools in the state.

1.1 West Virginia's "Basic Skills/Computer Education" (BS/CE) Program

The Basic Skills/Computer Education (BS/CE) program was authorized in 1989-90 and, beginning with the kindergarten class of 1990-91, hardware and software were installed in schools and teacher training began. BS/CE was intended to improve the basic skills learning of West Virginia's elementary students through technology. The program consists of three basic components: (1) software that focuses on the State's basic skills goals; (2) enough computers in the schools so that all students would have easy and regular access to the basic skills software; and (3) training for teachers in the use of the software and the use of computers in general.

Each year from 1990-91 onward and beginning with kindergarten, the State of West Virginia provided every school with enough equipment so that each classroom serving the grade cohort of children targeted that year might have three or four computers, a printer and a school-wide, networked file server. Schools could choose to deploy the computers in labs and centers or distribute them directly to classrooms. As that kindergarten class went up the grades, so did the successive waves of new computer installations coupled with intensive professional development for teachers and software chosen from either IBM or Jostens Learning. The software and training emphasized the basic skills of reading, mathematics and writing.

The BS/CE that students and teachers experienced was an obvious amount of new gear (either concentrated in a showcase lab or center or distributed directly to classrooms); new software that related directly to a consistent, statewide priority on basic skills instruction[1]; and intensive training prior to implementation coupled with continuous support during the early implementation. All elementary teachers on a given grade level were experiencing the same software, the same expectations, the same new challenges, and the same opportunities. BS/CE thus covered all the bases of technology integration—hardware, software, and professional development and involvement—and all in a concentrated, sustained and visible program.

[1] This analysis was designed as a study of the aggregate impact of all of BS/CE's features on educational achievement. It was not designed to measure the relative merits of the two software vendors, IBM and Jostens. The software packages that each made available were targeted on basic skills instruction. To make the software useful for teachers and to relate it to state priorities, the vendors mapped their packages onto the State's curriculum objectives. Finally, each package included Integrated Learning Systems features—student and class data reports to support individual, classroom, grade-level, and school-wide analysis and action.

BS/CE is important because of how it was done—the inputs—and because of what happened—the outcomes for students, teachers and schools. We first describe the program.

1.1A Policy Inputs

In program design, the grade-by-grade follow-through strategy is different from conventional practice. Because the State could target its expenditures in equipping a single year of classrooms, the concentration of computers potentially available per classroom was much higher than would be the case if the same number of computers were distributed evenly, and thinly, across seven times as many classrooms (K-6).

The investment in professional development also departs from the usual practice. West Virginia spent roughly 30¢ of every technology dollar on training, ten times the national average for schools. The State conforms to the recommendations of the U.S. Department of Education that 30 percent of the total technology budget be spent on professional development for teachers[2]. In one two-year period, 5,000 teachers were provided with professional development in a 'turn-key training' process provided by the State pursuant to a state contract with the software vendors.

In contrast to the ordinary *laissez-faire* local selection of software, the state provided two sources of software—IBM or Jostens—between which local jurisdictions could choose. Jostens offered the Jostens Learning System in Reading and Mathematics, and IBM made available their Basic Skills Courseware. The Jostens Learning System provided identical software across schools; therefore, students who used the Jostens Learning System in one school were exposed to the same intervention as students in another school. The IBM offering, however, included a number of programs from which teachers could choose[3]. Each software package was developed or adapted by the vendor to emphasize the basic skills targeted by West Virginia for improvement—reading and mathematics[4]. Each package was mapped onto West Virginia's statewide instructional goals and objectives.

The option of two providers—IBM and Jostens Learning—allowed counties to select the solution that most closely aligned with the educational philosophy of the district. While both solutions meet the intent of the state program, they differ in their approach. Both solutions are strongly correlated to national standards and state instructional goals. Additionally, both were available to be implemented in classroom or lab configurations depending on the individual school's choice.

IBM fosters a learning center approach in which students move in small groups to complete specific activities at various classroom or lab locations designated as centers. Each session begins with a whole group activity and then moves to independent or cooperative use of the computer and courseware. According to IBM, this approach promotes problem-solving and higher-order thinking skills. The courseware offered by IBM addresses reading, mathematics and writing skills, while offering the districts some range of choices among software programs as teachers build a solution that complements and extends classroom instruction.

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2 US Department of Education, *Getting America's Students Ready for the 21st Century*, Washington, DC, 1996. Most professional development took place during the school year. Teachers were paid their regular salaries and schools received paid substitutes.

3 Bouncy Bee Learns Letters and Words, The Children's Writing and Publishing Center, Combining Sentences Series, Cornerstone Language and Math Series, Exploring Math Concepts Series, Exploring Math with Manipulatives Series, Exploring Measurement, Time, & Money Series, Math Concepts Series, Math and More. Math Practice Series, Parts of Speech Series, Primary Editor Plus, Punctuation Series, Reading for Information Series, Reading for Meaning Series, Skillsbank 96 Reading & Mathematics, Spelling Series, Stories and More I & II, Student Writing Center, Touch Typing for Beginners, Vocabulary Series, Writing to Read 2000, Writing to Write Series.

4 The program as fielded in 1990-91, emphasized basic skills, and was targeted at the elementary grades. As a result, the software, especially the launch versions selected from the late 1980s available libraries, emphasized more drill and practice than would be the case in an initiative with access to current or future materials or one pointed at different policy goals.

Jostens Learning Corporation offers courseware that they believe addresses multiple instructional philosophies. The courseware allows the teacher to provide individualized instructional programs based on students' needs. The products are designed to enhance critical thinking skills through lessons for the reading, mathematics and writing curricula. The management system provides an assessment component with a variety of reporting options.

In practice, the implementation of both vendor solutions has become very similar. Both have made a strong effort to adapt their materials to the needs of the teachers and students in West Virginia. Both vendors provided staff development specifically designed to address issues targeted by the BS/CE program. Both vendors provided correlation matrices to the texts on the West Virginia adoption lists and to the standardized assessment tool selected by the state.

To fund this initiative, West Virginia used a per-student entitlement strategy rather than a grant strategy. Thus, *all* elementary schools received hardware, software and training, not just schools that successfully completed grant applications, as in many other jurisdictions.

The eight-year consistency with which the legislature has passed appropriation bills to support BS/CE purchases is equally remarkable. Funding has been about $7 million per year. The state's policy choices concentrated resources on a relatively small number of classrooms and that, in turn, enhanced the likelihood of a ratio of students to computers that would reach a critical mass. Second, the state invested in its teachers as seriously as it did in technology. Third, it instituted policies that simplified supervision, training and maintenance (the single hardware contract and the two vendor choice for software). Fourth, all schools were included and all elementary teachers were assured of their place on the implementation schedule. Finally, the legislature provided consistent and sustained funding. The net effect of those choices was a tightly focused program.

1.1B What Is BS/CE to Students and Teachers? The reality of any program differs by the participant's perspective.

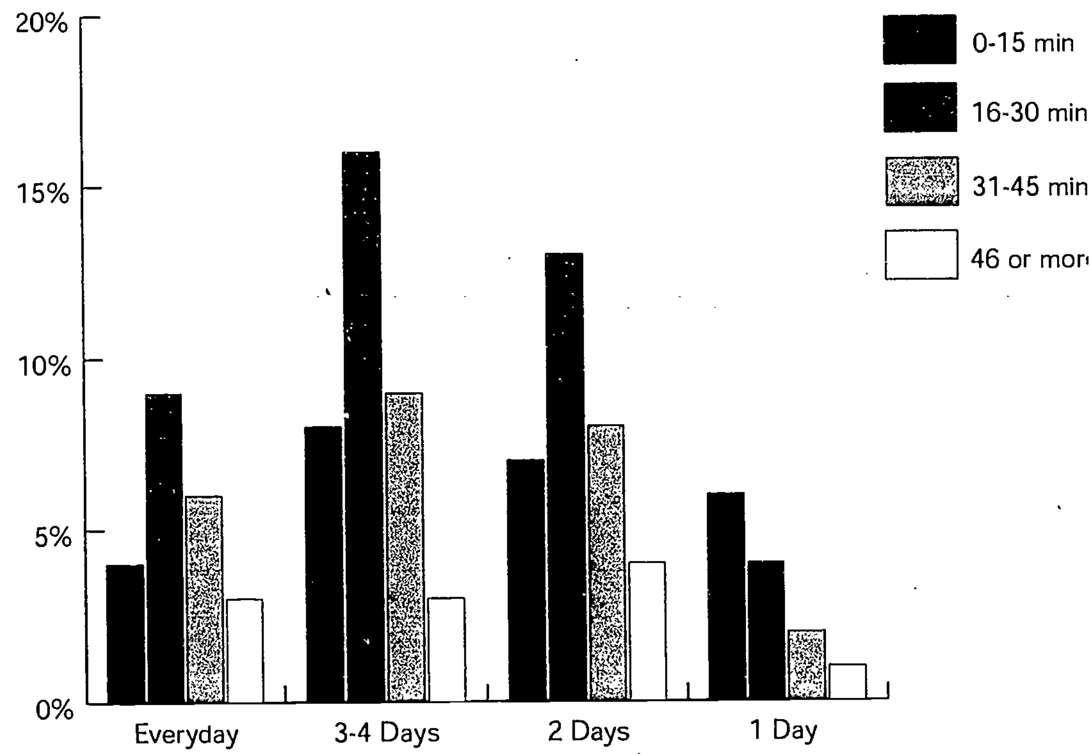
1.1B1 Students

For most students, BS/CE represented only two of the three components of the initiative: hardware and software. The conventional wisdom is that change is resisted, but 90% of the state's students thought these new technologies in the school were easy to use. Seventy-eight percent of West Virginia's fifth-grade students thought that the BS/CE computers had helped make them more successful as students. Two-thirds reported that they liked using computers "a lot"; more than half believe that computer technology is a "new basic" (two-thirds of the teachers have reached this conclusion).

The fifth-grade students reported the amount of time they spent working on the computer each week, with the majority spending an hour or more a week; 10% of the students spend more than two hours a week. Nearly a quarter of the students (22%) work on the computer every day and an additional 36% spend time on the computer three or four days of the week. (See Figure 1.) While BS/CE was intended to boost basic skills acquisition, the students inevitably learned about computers at the same time. After involvement in BS/CE, 43% report that they know a lot about computers.

Student attitudes and comfort with BS/CE and computers in general came from teacher encouragement, modeling, and support. Three-fourths of the students said they were encouraged by their teachers to use computers.

Figure 1. BS/CE Computer Use (Student Self-Reports)



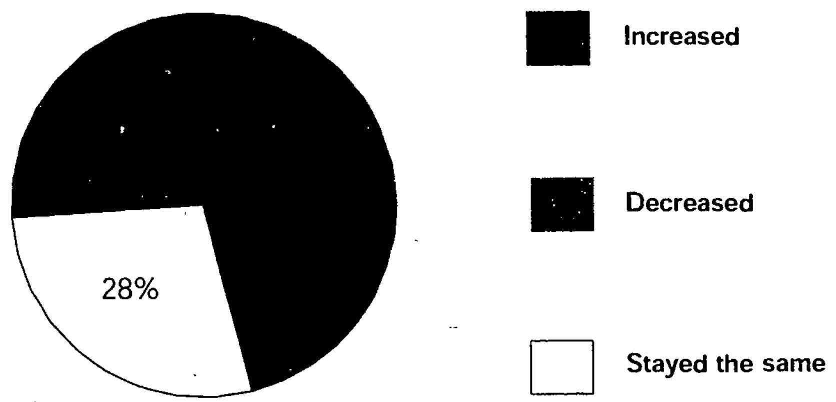
1.1B2 Teachers

Most teachers understood BS/CE as a three part initiative: hardware, software, and technology development, all directed at improving basic skills in students. The initiative sparked collaborative teaching practice, which was documented in our one-on-one interviews, case studies, and in the surveys.

For instance, in West Virginia we saw BS/CE teachers opening classrooms early to accommodate students who wanted to use the rooms' computers. We saw other teachers taking pages of student test data off the printer and talking with each other about their differing perceptions of the students whose records were being printed. In another school, we interviewed two teachers from the same grade level who worked together using BS/CE because they believed that each of them was strongest in a different dimension. One created a series of math lessons customized to local traditions; the other wrote the beginning of a movie script that the students had to complete for a writing project. These activities were used by all of the students in the two classes.

Our procedures allowed us to determine what attitudes were most related to student achievement and that discussion extends the picture of BS/CE as it was perceived by the teachers. A few facts pre-figure those results: first, almost half the teachers (46%) report that their enthusiasm for incorporating computers into their instruction has increased over the years. (See Figure 2.) Ninety-two percent of the teachers concluded that instructional technology was not just another fad.

Figure 2. Teacher Enthusiasm For BS/CE



Neither was the enthusiasm of the State's teachers diminished by the perceived requirement that they participate. Though BS/CE was technically not a mandate, when asked why they got involved, nearly half (49%) of the teachers said that initially they were "responding to a state-mandated requirement." But when we asked why they continued to be so involved, the percent reporting this 'compliance' motivation dropped to 24%. Teachers came into BS/CE because they were compelled to, and they stayed because they believed in what it could do for them and their students. Fifty-eight percent of all teachers surveyed reported, "I feel competent guiding student learning through the use of Basic Skills computers."

In addition to the enrichment and supplementary ways that teachers used BS/CE, they also used BS/CE as it was intended, for basic skills. In terms of the most to least frequent use by instructional purpose, teachers reported a mean of 4.40 for mathematics use and 4.06 for English/language arts use on a scale of 1 = None at all and 5 = Very much. Asked to estimate the amounts of time that students spent learning either mathematics or English/language arts with BS/CE computers, the majority of teachers chose the maximum time estimates possible. (See Table 1.)

Table 1

Teacher Estimates of Student Computer Use by Curriculum Areas

	Teacher Estimate of Amount of Student Use				
Curriculum Area	Percent Very Much	Percent Some	Percent Middle	Percent a Little	Percent None at All
Mathematics	62	26	9	2	1
English/language arts	57	24	16	3	1

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One of the objections to computer-based learning is that it takes time away from higher order, more creative tasks. We asked the teachers whether they agreed or disagreed with this point of view: "When students learn using computers, they typically reproduce knowledge rather than construct it." One-fourth agreed, but 31% thought that computers were prompting more advanced knowledge construction in their classrooms.

The same teachers described their own preferred roles as teachers in a more constructivist light ("coach" or "colleague" in the construction of knowledge) rather than in the traditional "source" or "master" of information.

1.1C Outcomes

West Virginia's recent history of educational achievement is encouraging. Test performance improved over the BS/CE years. For example, after the technology enhanced cohort arrived in that grade, statewide third grade CTBS[5] scores went up five points. Prior to that time, those scores had risen about 1.5 points per year, six points in four years. One interpretation of those trends is that the State's improvement trajectory was sustained and accelerated by BS/CE students.

The BS/CE cohort's fourth-grade reading scores (1997) are reported to be the second highest among southern states (only one point behind North Carolina). On a national basis, if the achievement scores of various states are "corrected" by income, that is, if the unearned increment of school achievement that states with high per capita income enjoy from the support that privileged families give their children's learning, then West Virginia's test scores improved more than those of any other state. In terms of per capita income, West Virginia is in 40th place: in achievement, it is in 17th place. Additionally, student attendance improved and early school leaving declined.

The balance of this report details the relationship between the BS/CE initiative and the achievement outcomes which can be associated with that initiative.

1.2 Research Methods

We know that these two events—a statewide, comprehensive instructional technology program and improved achievement scores—happened at the same time. This analysis tests the extent to which West Virginia's achievement gains are related to the BS/CE instructional technology initiative.

The importance of research methods goes beyond academic concerns. Policymakers at every level have been investing in instructional technology and have a right to know, "Does it work?" And, at every level, different functions compete for scarce public dollars. Should money be spent to hire more para-professionals or to extend the school day? Should we build new facilities or wire existing ones? Research evidence does not "make decisions": policy is shaped by the interests of various publics, by compromises and accommodations and by the momentum of existing arrangements. The evidence of research is only one part of decision making but, in its absence, decisions are made solely on grounds external to what best helps children learn.

[5] CTBS, California Test of Basic Skills.

Thus, the Milken Exchange on Education Technology commissioned research that would have several policy relevant characteristics. First, because states have the reserved power to determine schooling policy, they wanted statewide evidence. Second, because test scores are one central metric of school outcomes and children's accomplishments, they required an analysis of educational achievement, using conventional state level assessments. Third, because of recurrent skepticism about instructional technology[6], a well constructed analysis of results was needed to inform the public discourse and professional practice.

The hallmarks of a good evaluation design include: a sample selected to represent the population being studied; data that are valid, reliable, and from multiple perspectives; students as the unit of analysis; multiple forms of implementation documentation; and, the continuing cooperation of the group studied.

The first step in the analysis was a series of meetings to establish the feasibility of West Virginia as a study site. With the cooperation of key state leaders secured and with access to data assured, Interactive, Inc. was able to select a sample, gain entry to schools to administer paper and pencil surveys to all fifth-grade students and all teachers; interview all fifth grade teachers, all principals, and selected students; and attach Stanford 9 achievement data for two years to all students in the sample.

1.2A Sample

Since the purpose of this study is to examine the link between technology and student achievement, the unit of analysis is the student. Because we need to document specific implementation, teacher attitudes, and other variables in relation to each student we studied, a random selection of students statewide was not feasible within the time and cost restraints of the study. Additionally, because this is a retrospective longitudinal study which collects up to five years of data on schools, classrooms, and students, we needed to use our resources to insure as much depth and accuracy in these data as possible. Resource considerations prohibited both local data collection in every school in the state (or even a random selection of a representative sample of schools) and a random sample of students, since the latter choice would require the research team to collect data in each student's school. Thus, we used schools as an initial stratifier for the sample.

In order to assure that the schools selected would provide a representative sample of West Virginia BS/CE students, we selected 18 schools as the initial stratifier from which we would study all students in those schools. The schools were selected with the help of a state education advisory group based upon achievement, perceived BS/CE intensivity, geography, vendors, and SES.

Based on 1995-96 3rd-grade CTBS scores, the 18 schools selected for study range from high to low in school level achievement. Furthermore, achievement varies naturally among students and that is appropriate since the unit of analysis here is the student.

Our next concern in sample selection was to find varying student technology experiences. Consensus among West Virginia state officials, software vendor consultants with regular access to the schools, and current research on student technology experience is that student technology experiences vary as much within group (across students in a school) as among groups (across schools). Therefore, selecting schools based on high vs. low technology is not necessary to insure a wide variance in experience and attitudes.

[6] The skepticism is often a by-product of the competition for scarce resources. In the struggle to get budgets for their preferences, the partisans of any initiative will question the evidence on which the competition bases its claims.

However, as an additional safeguard, we chose schools which, based upon the judgements of both West Virginia Education officials and the software consultants who are in those schools regularly, were perceived to have a range from most to least technology practice.

Another criterion in the selection of the schools was geography. State officials believed this an important variable for sample inclusion—both in terms of variance in achievement scores and in local factors which may have an impact on technology use. As a result of discussions with the state education advisory group, we divided the state into four geographic areas which represent distinct geocultural and educational variables: Northern panhandle (adjacent to Ohio and Pennsylvania), Eastern panhandle (essentially a suburb of Washington D.C.), South (rural and adjacent to Kentucky and Virginia), and South Central (the capital, Charleston and its surrounding counties).

An additional and convenient geographic stratifier in selecting the sample is the eight Regional Educational Service Agencies (RESA). The eighteen schools for study come from all four geographic areas and all eight RESAs.

Part of the policy significance of this analysis is West Virginia's unique statewide implementation strategy which required a choice between two software vendors: IBM and Jostens Learning Center. Additionally, the majority of the implementation assistance came from the software vendor consultants, not the state. Therefore, software is an important consideration in reconstructing implementation and individual experiences. We selected schools so that the proportion of Jostens and IBM programs used by students would be proportional to their use statewide. As a result, twelve of the schools selected were Jostens' schools and six were IBM schools.

Based on West Virginia Department of Education data on the percentage of students receiving free and reduced lunch, the 18 schools also range from high to low in terms of socioeconomic status.

The result is a sample of 18 schools which vary with respect to:

- achievement test scores,
- BS/CE and technology experience,
- geography,
- software vendors, and
- community SES.

The next step in the sample selection was to determine which students from the 18 schools would be studied. Prior to the 1996-97 school year in West Virginia, the CTBS was administered for the 3rd-, 6th-, 9th- and 11th-grade students only. Beginning in the 1996-97 school year, the Stanford Achievement Test (9th Edition) was administered to all students in grades 3 through 11. Therefore, the current 5th-grade students are the only students in the state of West Virginia for which the state has three consecutive years of achievement test data and who have had any BS/CE exposure. Because of BS/CE's follow-through phasing, the current 5th graders are the students for whom technology has been most available. Therefore, we documented the experiences of all current 5th-grade students from their first year of experience with BS/CE through their current experience.

Our student sample included all 950 students in 5th grade in the 18 stratified schools. To generalize to all K-6 students in West Virginia from K-6 (N=161,231) at a 95% level of confidence, we would have needed data on 384 students. This sample, then, is representative both in that it includes students with a range of achievement, technology experiences, geography, and SES, and it is nearly three times more students than necessary to assure confidence in the accuracy of the analysis.

1.2B Data Collection: Inputs

Because this study is an examination of the relationship between technology use and student achievement, we had to determine how we would document technology use as well as other variables which might influence use. The technology factors included: BS/CE use; other technology use; attitudes toward technology; home technology practices; and other demographic and school variables.

To determine student use and attitudes, we used student and teacher survey and interview data. Input data were collected in the following ways.

- Surveys of 950 5th-grade students, using a 33-item paper and pencil survey. This survey focused on BS/CE use; attitudes toward schools, computers, and technology in general; and other factors which relate to technology use and learning. This survey allowed students to record their technology experiences from kindergarten through their current school year.
- Surveys of 290 third- through fifth-grade teachers, using a 99 item paper and pencil survey. We administered this survey to all the teachers in all 18 schools in an attempt to capture data from those teachers who had taught our fifth-grade student sample for the past three years.
- Interviews with all fifth-grade teachers in the 18 sample schools.
- Interviews with all principals in the 18 sample schools.
- Interviews with selected early-grade teachers in the sample schools.
- Analysis of documents in each school related to technology planning and implementation.

In addition to the data from students, we asked teachers about student use as well as their own attitudes and practices. Ninety-one percent of the teachers were female. Sixty-three percent have been teaching for more than 21 years; 29% for 13-20 years; 5% for 6-12 years; and only 4% have been teaching for 5 or fewer years.

We interviewed all the fifth-grade teachers and selected early-grade teachers in each school to try and understand more completely how BS/CE was implemented in their classrooms and what this meant for how students learn. These teachers provided current use data for each student on BS/CE and their own past curriculum use of BS/CE.

During the winter of 1998, each school was documented, on site, by an Interactive, Inc. field researcher. To determine if other initiatives were happening or if political or internal issues might have affected both implementation of BS/CE and student involvement, we interviewed all principals, fifth-grade teachers, and selected early-grade teachers in the 18 schools. In addition, we analyzed classroom, school, and state documents to complete the case descriptions.

1.2C Data Collection: Outputs

Once we collected the student use data and the BS/CE descriptions, we turned to measures of achievement. Prior to 1996, the West Virginia Department of Education administered the CTBS to all students in grades three, six, nine and eleven. Beginning in the 1996-97 school year, a new statewide assessment program was implemented with all students in grades 3-11 taking the grade-appropriate Stanford-9 achievement test. Thus, we had two years of Stanford-9 test score data to consider, and an opportunity to consider the relationship between gain scores and BS/CE.

The scores that were used in the analysis were scaled scores on the Stanford-9 achievement test. Because scaled scores are normed against a nationally representative group, they are appropriate for comparison purposes and for the computation of gain scores. The Stanford-9 achievement test is divided into a number of subtests, and where appropriate, those scores are reported. Our focus is on gains in "basic skills," a score computed and reported by the West Virginia Department of Education for comparison purposes, and a score that measures the math, reading and language arts areas that were the focus of BS/CE. Scores on each of the three areas could range from 400 to 800. For 1998, the range of "basic skills" scores in the state was from 547 to 766 and the average gain score was 14 points.

In this study, we computed gains in Stanford-9 results to measure student achievement from one year to the next. Gain scores represented the difference between the scores on a basic skills combined measure of math and reading and language arts from the 1996-97 test to the 1997-98 test. Thus, achievement was represented by Stanford-9 scores on reading, language arts and mathematics for all students in the sample for 1997-98 and 1996-97

1.2D The Model: Access/Attitude/Training

To determine the relationship between the BS/CE inputs and the achievement outputs, we analyzed our data using a model that includes access to software and computers, attitudes toward technology, and teacher training and involvement:

The Model: Access/Attitude/Training

(1) Software and Computer Availability and Use (software focused on basic skills, computer availability, availability of other software and technology programs, time using basic skills software)

\+ **(2) Attitudes Toward Computers** (student attitudes toward computers, teacher attitudes toward computers)

\+ **(3) Teacher Training and Involvement in Technology Implementation Decisions** (teacher professional development and involvement in implementation decisions)

= **Predicted Change in Acheivement Test Scores**

We speculated that Stanford 9 achievement gains would be the greatest in schools with the highest amounts of the model components.

1.2D1 Software and Computer Availability and Use

This component includes four items: basic skills software, hardware availability, availability of other software and technology, and time spent using basic skills software.

(1) Basic Skills Software. The development of interactive software to teach basic skills at each grade level and the availability of that software to students and teachers is likely to result in student use of the software. Data for this variable comes from observation and the West Virginia Department of Education.

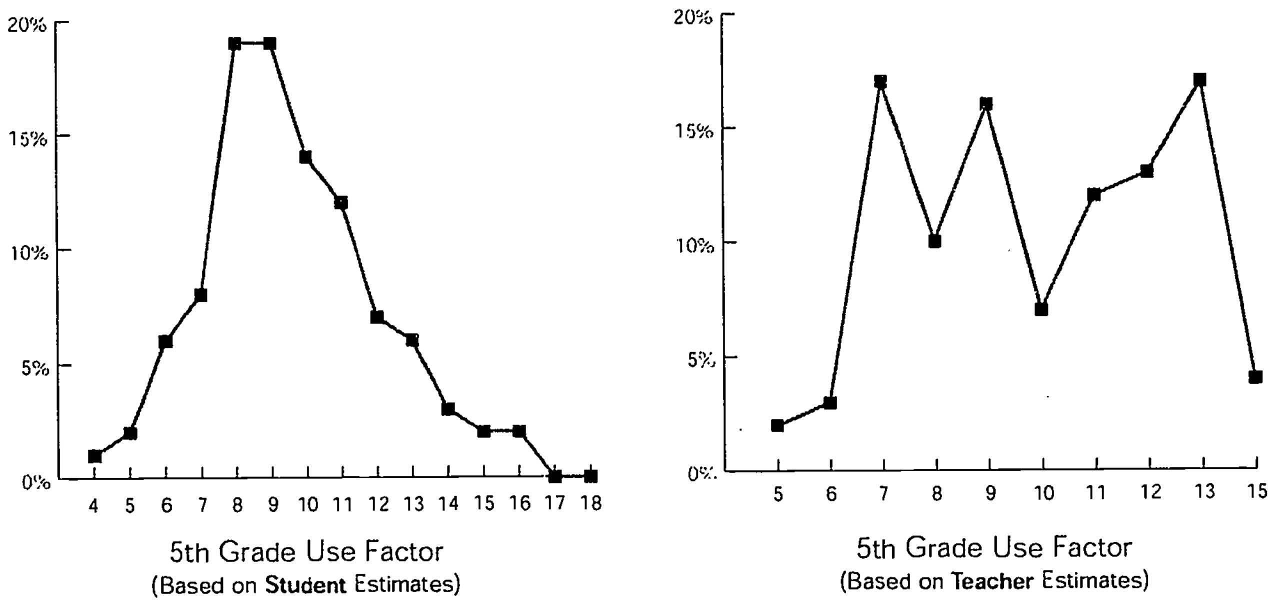
(2) Computer Availability. The more computers that are available to students and the more students report that there are computers available when they want them, the more likely it is that student computer use and the technology implementation can occur. Data for this variable comes from a yes/no response on the student survey.

(3) Availability of Other Software and Technology. This is a school wide variable which was measured in the site visits by inquiry from principals, teachers, and students as well as by observation of technology initiatives and the collection of documents submitted to the State Department of Education.

(4) Time Using Software. This component of the model includes both time spent on BS/CE and time spent using other software. We asked teachers to describe their students' use of computers and BS/CE. Their answers resulted in a factor which combined the responses to six questions in the teacher survey and represents the amount of time that teachers estimate students use the technology in math, reading, and writing. Total scores on this factor ranged from 5 to 15, moving from none in math, reading, and writing to 60 minutes or more in math, reading, and writing.

A series of questions to students resulted in a similar student-reported technology use factor. Teacher and student measures of time were closely correlated. Total scores on this 18 point factor ranged from 4 to 18, from zero in math, reading, and writing to 60 minutes or more in math, reading, and writing. (See Figure 3.)

Figure 3. Time Using BS/CE Computers



The second "use" component focused on technology use other than BS/CE. We predicted that time using any instructional technology leads to increased skill and comfort with computers and the technology and basic skill learning of the primary initiative. The use of technology independent of BS/CE was documented in the qualitative case studies in each school and each classroom. The case study data were then recoded into a four option variable ranging from "no additional technology" to "extensive additional technology."

1.2D2 Attitudes Toward Computers

The attitude component includes both student and teacher measures.

The student attitude factor combined the results of student responses to two survey questions: the scores ranged from two to four. The model predicts that the more positive students feel about computers and technology, the more likely they are to use BS/CE software.

Two factors represented teacher attitudes. The first was a factor combining the results of questions from the teacher survey focusing on teachers' comfort level and confidence in using computers. The second is a factor that combined the responses to two questions which tapped teacher willingness to continue learning about computers and technology.

1.2D3 Teacher Professional Development and Involvement in Implementation Decisions

This component includes both the training that teachers received and their involvement in the planning and implementation of BS/CE.

Teacher training is the amount of time teachers spent learning on the computer on their own. We predicted that the more teachers are involved in development of the technology implementation plan, the more likely the implementation is to be carried out. We measured this involvement using questions on the teacher survey. Teachers responded to a five point Likert scale. The results were clarified through teacher interviews.

1.2E Analysis

After factor analysis had established the reliability and validity of the three components just described, the relationship of BS/CE to student achievement gain scores on the Stanford-9 was analyzed through multiple regression analysis.

Interactive, Inc. circulated all reports in draft to officials from the West Virginia Department of Education for correction of matters of fact and for comments on our interpretations and conclusions. [*Nota Bene*: responsibility for this analysis, its conclusions and recommendations rests solely with the authors and does not reflect the policies of either the West Virginia Department of Education or the Milken Exchange on Education Technology.]

1.3 Summary

The net result of the state's initiative, its accomplishments and the procedures for this analysis makes West Virginia a potentially illuminating case study of innovation in instructional technology. The implementation was statewide yet tightly focused. The outcomes were significant in terms of policy and of statistics. And the events and the outcomes have been comprehensively assessed.

2.0 RELATIONSHIP OF BS/CE TO STUDENT ACHIEVEMENT

To examine the relationship between the BS/CE experience and student achievement, we computed gain scores on the Stanford-9 for each student from 1996-97 to 1997-98. Additionally, for each student we gathered data for each of the regression model components which measure:

- Software and Computer Availability and Use,
- Attitudes Toward Computers, and
- Teacher Professional Development and Involvement in Technology Basic Skills Implementation Decisions.

2.1 BS/CE's Effect on Student Achievement

With the student as the unit of analysis, we examined the relationship between how much of each of the model variables that student had experienced and her or his gain scores on the Stanford-9.

The more of each of the model components that the student experienced, the higher the gain score on the Stanford-9. Specifically, the BS/CE technology regression model accounts for 11% of the total variance in the basic skills[7] on the Stanford-9 achievement test. (See Table 2.)

Table 2

Model Summary: Achievement gain scores of the fifth-grade students.			
r	r^2	adjusted r^2	std error of the estimate
.331	.11	.094	14.8317

Thus, student gain scores can be partially explained by a model composed of factors that describe the overall BS/CE experience, an impact which is powerful and practically significant; it is also statistically significant at more than the .001 level. More to a practical point, an 11% improvement in test scores would be welcomed by most students, parents and educators.

2.2 Policy Significance of the BS/CE Effect on Student Achievement

Analysis indicates that test scores of our student sample improved from 1996-97 to 1997-98. Conventional procedures ask, "What percentage of that whole gain can be explained by the BS/CE initiative?" Our data indicate that 11% of the reason why student scores increased was because of BS/CE.

What does this mean? Is 11% more than just statistically significant? Does it have any practical value to students, educators and policymakers? We think so. To understand what the 11% of explained variance means, it is important to understand all the influences on student achievement, the most significant being family background.

[7] An average of the students' Total Math, Total Reading and Language scores

Family background explains a great deal of why some children do better than others. Since James Coleman's 1965 research, we have known that children's achievement in school is conditioned more by what they bring to school than by what schools are able to do with them. Consider:

> (D)espite the wide range of diversity of school facilities, curriculum and teachers, and despite the wide diversity among student bodies in different schools, over 70% of the variation in achievement for each group is variation within the same student body (James S. Coleman, et al, *Equality of Educational Opportunity*. Washington DC., US Department of Health, Education and Welfare, 1966, p 77).

In thinking about schools, this difference between what schools can and cannot influence is intuitively and practically obvious. Imagine trying to search out the explanations for gains in test scores between two groups of children. One group lives in houses where the following are customary: daily reading that is modeled by adults and encouraged for children; availability of books and magazines; frequent use of computers and computer games; after school learning and enrichment activities; parental or other adult supervision of homework; and, visits to museums, art galleries, and science sites.

The other group of children live in homes where: there are no books; reading is not modeled, encouraged or frequent; unsupervised television is constant; there is no computer; there is no after school enrichment; there is no supervision with homework; and, there are no visits to cultural events of the sort reflected on achievement tests.

To document the amount of learning for both groups of children, an achievement test is administered which measures: knowledge of mainstream culture; familiarity with standard English; art and science experiences outside the classroom; and the benefit of extra drill and practice in the basic skills.

It is not surprising that the children with all of the educational and cultural extras provided by the family and tested by the assessment do better than the children who do not have the related experiences. This is the power of the family and of economic privilege. According to Coleman, the resources of families, the culture, the media and the peer group account for 70% of the differences in student achievement.

If the performance of children depends heavily on the characteristics of the families they come from and if we further understand that those family characteristics are for the most part beyond the reach of public policy (for example, proscribing divorce, prescribing post-graduate education for parents, and providing all families with equal social capital), then we ought to concentrate our attention on the things that are, in fact, accessible to influence by *school* policy.

If, as Coleman and others assert, 70% of the variation in test score performance relates to family and other background factors, that leaves 30% that schools can influence. We call that 30%, "school accessible performance"[8].

This analysis documents that as much as 11% of the gain score variance for one year can be explained by BS/CE. Thus, BS/CE explains more than a third of the school reasons why students' achievement scores improved. Said another way, of all the factors that can affect a child's learning, about 30% is within the school's sphere of influence. The BS/CE technology initiative explained nearly 11 of those 30 percentage points.

[8] The school improvement literature concentrates on the institutional side of this equation, not on the larger family and community surround. Ideas of "school effects" and of "within school factors" can be found, for example in Michael Rutter, Barbara Maughan, Janet Ouston, Alan Smith, *15,000 Hours: Secondary Schools and Their Effects on Children*, Cambridge, Harvard University Press, 1979. See also, Peter Mortimore, Pamela Sammons, Louise Stoll, David Lewis, Russel Ecob, *School Matters: The Junior Years*, Somerset, Open Books, 1988.

This effect is reflected in the change in West Virginia's rankings among other states. During the period studied, West Virginia moved up the list of states in the nation rank-ordered by school achievement from thirty-third to seventeenth best. Since we can establish the fraction of achievement score gain that is related to BS/CE, it is reasonable to assign some portion of the credit to that initiative. It is also reasonable to believe that the effects of BS/CE, although impressive, are underestimated.

There are two additional reasons to believe that the reported gain scores underestimate the total effect of BS/CE. The 11% of the gain score variation explained by BS/CE was between 1997 and 1998 scores. Those gains happened between the fourth and fifth grades and it is very likely that there were earlier increases, attributable to this initiative; between the third and fourth grades and the second and third grades and so on back to the beginning. Thus, the cumulative effect of BS/CE most likely accounts for more than the 11% of the single-year gains that we found.

We also suspect that the gain scores reported are unnecessarily conservative because current hardware and software is more powerful than what was implemented in BS/CE's early years. Current technology is likely to yield even larger gains.

If BS/CE can be credited with some considerable effect on statewide test score gains, then did BS/CE "make children perform better?" The question is reasonable but on the evidence we have, strictly interpreted within the canons of social science, we cannot say with certainty. To be able to do so, the State would have had to have randomly assigned some students to BS/CE and randomly assigned other students to conditions where BS/CE was not available. While that might be good social science, such practices are poor and probably unethical public and educational policy.

Thus, as a consequence of the statewide implementation, it was not possible for us to compare control group schools with the BS/CE schools. And, the achievement score record prior to 1990 is insufficiently detailed to support a pre/post inquiry. As a result, our's is an analysis of correlations (things that vary together), not an analysis of causation[9]. No one withheld instructional technology from half the children; instead the State made BS/CE available to all children. However, as is usual in any initiative, some students experienced more of each of the BS/CE technology components than others, so what we have is a situation where all students received something and some students received more of some things than did other students. Those combinations are not uniform and vary by student, even within the same school or the same classroom. And those variations make possible the procedures of this inquiry.

As important as the procedures of social science research are, the needs of policymakers are also legitimate, so it is possible and sometimes helpful to interpret correlational data to suggest causality[10]. We have done so in this instance, suggesting that the unstandardized betas that we report are indices of the effect of the related BS/CE component on Stanford-9 gain scores. (See Section 2.3.)

We can help with the "What works" question by first, assessing the statistical significance of the numerical findings. Big findings may suggest big relationships. Second, we can ask about other explanations for the findings. Sometimes those alternate explanations can be disposed of; sometimes they can be understood.

[9] The absence of findings that rise to the level of causation is the norm in social policy. Virtually no decision in public schooling is informed by causal analysis —not finance decisions, not racial integration decisions, not curriculum or testing or personnel selection decisions.

[10] Pedhazur and Schmelkin (1996) believe that the unstandardized betas in nonexperimental research can be interpreted as indices of effect if the model is specified based upon theoretical foundations and previous research. Because our model is so specified, we maintain that our unstandardized betas indicate effect.

In this case, we believe that the several dimensions of BS/CE explain a substantial fraction of the school-accessible performance. An explanation of that magnitude is intrinsically worthy. The part that is not explained by BS/CE may have to do with initiatives such as statewide standards and testing, or West Virginia's "Unified School Improvement Plan(ning)" or school-site accreditation visits coupled to the possibility of probation. Empirically determining the effect of those procedures was not within the scope of this work, but we did examine nearly 50 other variables for alternative explanations and found none[11]. (See also "4.0 Additional Explanations For Test Score Gains.")

We believe that reasonable people, experienced with school policy, will find that this analysis supports the conclusion that instructional technology is a powerful assist to children's achievement[12] and thus to school improvement.

2.3 Effects of the Components of BS/CE on Achievement

Public policy has a continuing interest in answers to the "What Works?" question. Here, the *whole BS/CE program* makes a difference. No single component is sufficient to account for the BS/CE-associated outcomes and neither, probably, would it have been sufficient to maintain this program for only a few years.

It is not surprising that no single component dominates. Putting hardware in a room without training teachers or otherwise supporting the integration of technology into the classroom cannot be expected to make a difference. It is the cumulative effect of the several variables that compose the model that is important.

The several factors of our model resemble the several components of BS/CE policy. Statistically, as practically, it takes multiple dimensions to make a difference. The model demonstrates that it is software specific to the purposes of basic skills achievement, availability of computers, teacher training and involvement in implementation decisions, positive student and teacher attitudes toward computers, and time spent using the software that lead to achievement gains.

Taken together, these factors account for 11% of the variance in basic skills gain scores at more than a .001 confidence level (n = 502).

The three components of this empirically-derived model—access, attitude, and training—are similar to what leaders in instructional technology advocate. Unless there is sufficient equipment and opportunity to learn (access) there are unlikely to be effects from instructional technology. And, unless teachers have a chance to learn about the technology and how it may make them and their students more successful (training), they are less likely to believe it can help (attitude) and, in fact, to use it.

[11] For instance, we examined the effects of several student, teacher, and school variables on gainscores in our model creation and testing and found no additional explanatory power, for the analytic model, from these variables. Student variables tested include race, sex, age, geography, homework support, familiarity with Internet and E-mail, attitudes about school, attitudes about learning, time spent on homework, grades, and other achievement measures; teacher variables include attitudes, pedagogical philosophy, experience with computers and software, attitudes toward state initiatives, attitudes about teaching, attitudes about student learning, cost to teacher (in time, etc.) of implementation, professional development, homework expectations, and attitudes about families; district variables include local political actions, changes in administration, additional initiatives, deployment methods, availability of labs, and colleagueship.

[12] 54% of the teachers thought that BS/CE was instrumental in test score gains.

The teachers' confidence in using computers and the amount of time they spend using them are a bundle of attributes that may be influenced by experience, professional development and the teachers' perception of their principal's leadership. The teachers' attitudes and behaviors also interact with what the students' experience—increased use and positive attitudes toward computers.

We constructed the model first to test the possible relationships between BS/CE and student achievement and second to illuminate how BS/CE is probably making a difference with students. Empirically, we know that the complex of factors listed above will explain the amounts of achievement gain we have reported.

Practically, it is likely that BS/CE is having its effects through its ability to impact students through the model factors. With students, for example, the availability of computers and teacher encouragement are likely to increase computer use and, as use increases so does the amount learned and thus (probably) achievement. Similar logic applies to teachers. As BS/CE has rippled through the faculty culture over the years, it has changed attitudes and that becomes part of the intervention, part of the effect and part of the success.

For example, 69% of the students thought computers were as important as "reading and writing." Sixty-six percent like computers a lot, only 5% do not like computers. Sixty-one percent report that their teachers encouraged them to use computers.

School reform is often criticized for relying on "The Magic Feather Principle;" the idea that there will be a singular solution to complex problems. West Virginia's BS/CE model used multiple interventions to support and change multiple functions of teaching and learning.

2.4 Access/Attitude/Training Model Effect Size

As noted in section 1.2D, there are three major components of the technology initiative under study:

- Software and Computer Availability and Use (software focused on basic skills, time using BS/CS, use of other computer technology initiatives, availability of computers),
- Attitudes Toward Computers (student attitudes toward computers, teacher attitudes toward computers),
- Teacher Training and Involvement in BS/CE Implementation Decisions. (See Table 3.)

Understanding the strength of each of the model components is best done by examining the betas. While betas are a kind of effect size, they are not a straightforward measure, especially in the social sciences where variables are often inter-correlated. However, where a model is well specified, even if the study is not experimental, it is possible, particularly for policy purposes, to interpret unstandardized betas as indices of effects.

In our case, all of the components of this model stand as independent variables because there is very little correlation among and between them. The correlation between variables ranges from a low of .079 to a high of .224 and, thus the model has relatively low multicollinearity among its components. The tolerance for each variable in this model runs from .564 to .971, where the value is the proportion of variance unique to each variable. Six of the nine variables report tolerances in the 80th and 90th percentiles, while three hover at about the 60th percentile.

Table 3

Access/Attitude/Training Model Effect Sizes

Unstandardized Coefficients Standardized Coefficients

	B	Std. Error	Beta	t	Sig
Hardware and Software Access and Use					
Computer and BS/CE Use	1.453	.272	.240	5.338	.000
Software Access	5.958	1.470	.184	4.054	.000
Computer Access	2.126	1.347	.068	1.579	.115
Other Technology Access	.715	.659	.051	1.086	.278
Attitudes					
Student Attitudes Towards Computers	2.742	1.222	.099	2.243	.025
Teacher Attitudes Towards Computers	1.069	.434	.123	2.461	.014
Teacher Confidence	.310	.584	.030	.530	.596
Teacher Training and Involvment					
Involvement	-1.959*	1.059	-.097	-1.851	.065
Training	1.109	.656	.095	1.619	.091

*Negative numbers indicated higher teacher involvement.

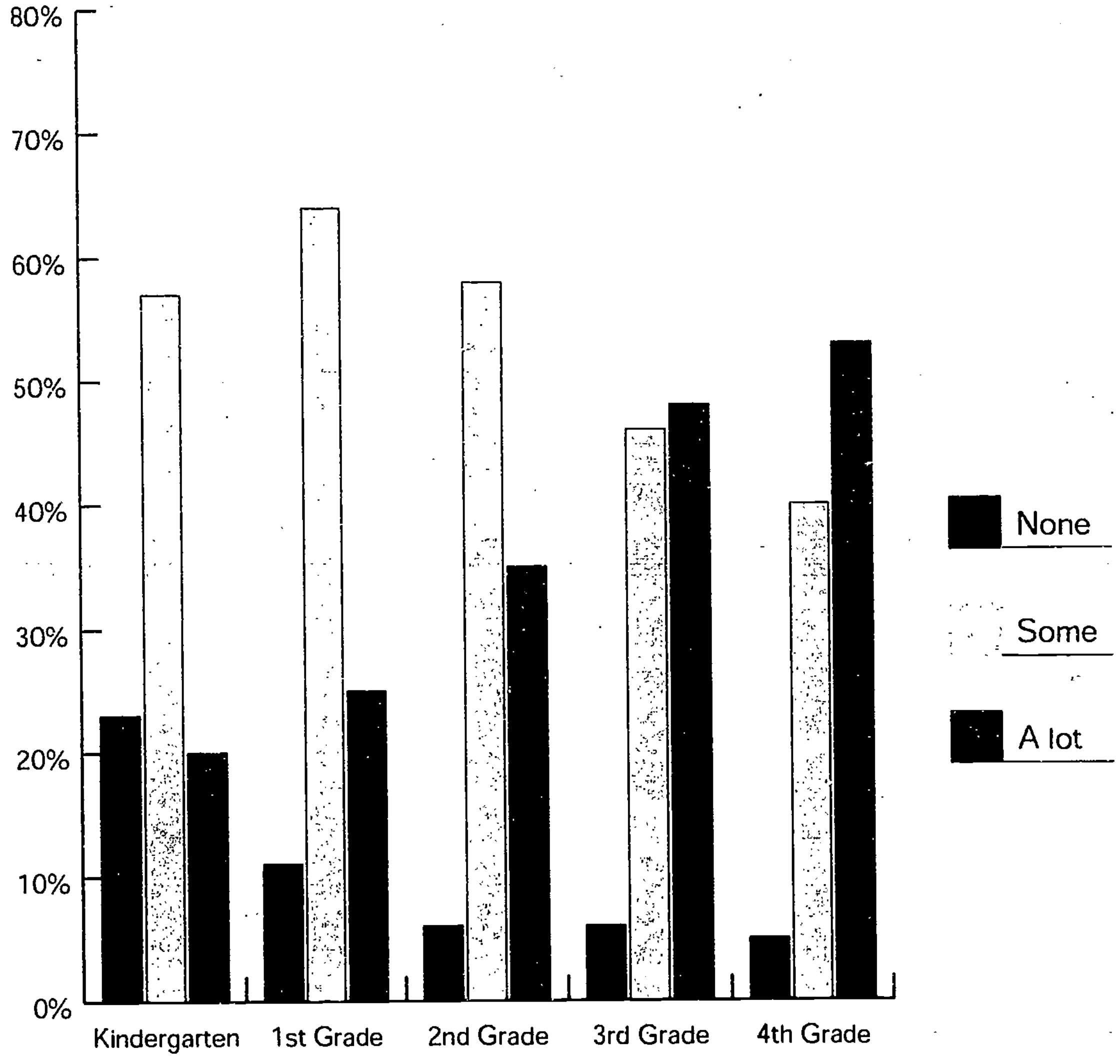
The meaning of the unstandardized betas tells us how much of an effect the nine variables that make up the three components of our model have on achievement, which in our case means that if all the components of the model are in place, achievement increases by between eight and ten months.

In schools that are hard-pressed to find time for all the mandates and all the required classes, time counts. In this analysis, "time" has two facets—the frequency with which BS/CE was used in any given year and the repeated, cumulated experience of BS/CE over the years.

The variable that measures reported instructional time in a year accounts for more of the difference than any other. The relation between time-on-task and learning gains is commonly observed. Extending the school day or year, cutting recess, dropping curriculum topics all make possible increases in time-on-task. What is different here is the use of technology to increase time-on-task. In a direct instruction, teacher-centered classroom there are a fixed number of minutes for a teacher to deliver instruction. When students use computers to work independently, the amount of student time-on-task can be multiplied independent of the limits on the teacher's agenda and availability.

Teachers make decisions about classroom time but so do state policymakers. BS/CE has been sustained over an uncommonly long interval, seven years. Students reported increased computer use every year from kindergarten through the fourth grade. For example, the percentage of students who described themselves as using "BS/CE computers a lot" increased from 20% in kindergarten to 53% in the fourth grade. Similarly, the earlier in their school careers that students began using computers, the more likely they were to continue intensive use. (See Figure 4.)

Figure 4. BS/CE Year-to-Year Computer Use



And, almost half the teachers became more enthusiastic about BS/CE as time passed. Neither would have happened without the willingness of the state's policymakers to keep instructional technology at or near the top of the priority list. We believe that time within the school day and year AND time across the student's life in school are part of the context for the achievement score gains.

2.5 The Distribution of Achievement Gains Across Groups of Children

The benefits of BS/CE fall differently by type of child. Gender and SES effect how well the model predicts achievement.

2.5A Growth for All Students

The amount of the gain score changes explained by BS/CE are significant in both policy and statistical terms. But, gain score differences focus the amount of change in one child or group compared to the amount of change in another child or group. What they do not reveal is whether or not the whole group was getting better and, in West Virginia, it was. In addition, students were able to recognize the relationship between their computer experience on BS/CE and their learning gains: Seventy-eight percent of the fifth graders thought that computers had helped make them better students.

The effect of the BS/CE technology initiative on student achievement can be illustrated by thinking about a bank of elevators. All the elevators are carrying passengers up, but their speeds may vary. In addition, passengers get on at different floors and get off at different floors. All passengers get someplace in the elevator; they start at different places and stop at different places, and they all go up. It is important to see that, although they start in different places and some get to the top faster than others, all the passengers are being lifted.

2.5B Equity Effects

The data indicate that BS/CE helped all children learn and it helped the neediest children the most! (Special education students reported the same amount of time on BS/CE computers as regular education students). Those children without computers at home made the biggest gains and that is good news for public policy—the children who most need the public school can be helped by this sort of policy. The schools we studied were chosen to represent a range of socio-economic characteristics. Some were urban, suburban and rural. Some schools served decidedly higher income families than did others.

The "Digital Divide" is mapped by those West Virginia students who do (62%) and do not (38%) have computers at home. Those without computers at home gained more in:

- total basic skills,
- total language,
- language expression,
- total reading,
- reading comprehension, and
- vocabulary.

The Access/Attitude/Training Model explains more of the basic skills gain scores for students who report lower grades than for students who report higher grades. For students who report receiving grades of C, the model explains 19.3%, versus 15.6% for students who report grades of B, and 10.7% for those reporting As.

Thus, BS/CE is more strongly related to gains for students who have less family and social capital and for students who do less well in school.

The chronic challenges of race and education condition us to expect lower achievement for some children than others. It is progress that in West Virginia, there were no differences in gain scores between white students and non-white students. On 1998 achievement, there were no differences overall, but white students achieved higher scores on listening, vocabulary and reading.

2.5C Gender

One regularity of both the technology and the gender literatures is the relative disadvantage of girls with respect to technology. It is progress that girls and boys had the same access and the same use of computers in West Virginia.

While there are no differences in the amount of use between girls and boys, the girls were more likely to see computers as a tool and the boys as a toy; boys are more likely to report that computers are fun.

Equal access and use of computers and software by girls and boys in West Virginia proved important in terms of girls' comfort with and attitudes toward computers. The more years that girls report having used computers, the more they like them and the more they report knowing about them. Unlike many girls, the girls in West Virginia are more likely than the boys to say they know more about computers than do boys. In addition, the girls reported finding computers more accessible than their teachers to their particular learning needs; girls are more likely to consider it easier to learn from computers than from their teacher. This finding might indicate that computers, unlike some teachers, respond in the same ways to both girls and boys and that either sex can ask questions, linger, or repeat activities on a computer.

In terms of gain scores, there were differences in only two areas related to gender—girls gained more in social studies and boys gained more in spelling. In math and reading, there were no gender differences. However, for the actual 1997-98 scores, girls did better in language, reading and study skills and boys did better in spelling. There were no gender differences in mathematics in 1998.

The Access/Attitude/Training Model is a more powerful predictor for boys than for girls. The model explains 16.1% of the basic skills gain score for boys, compared to 11% for girls. This is probably because of the difference in 1998 achievement on the language subtests on the Stanford 9. Because girls did better than boys on those language subtests, and because language and reading were improved by using the BS/CE technology, the more boys used BS/CE, the more likely they were to improve on Stanford 9 measure of language.

2.6 Teachers and BS/CE

Fifty-one percent of West Virginia's teachers are confident in using computers in their teaching, only 19% are not. Two-thirds say they are very interested in computers: a third believe that technology has "empowered" them as teachers. Half the teachers thought that technology had helped "a lot with West Virginia instructional goals and objectives."

We asked teachers to grade themselves according to how skillful they were in using computers for various functions. Typically, the closer the activity is to the "performance art" core of classroom work, the lower the marks teachers give themselves. While West Virginia teachers select "word processing" as their most skillful application, the next highest rated functions are central to teaching. The table below includes comparison values from another large-scale analysis of teacher use of technology.

The skill levels in delivering instruction, planning lessons, managing paperwork, and word processing of West Virginia's teachers who had computers in their classrooms were significantly higher than those who had computers in the labs. (See Table 4.)

Table 4

Teacher Self-Estimates of Skill Levels for Various Functions (N = 290)		
Function	Mean Score* West Virginia	Mean Score New York
Delivering Instruction	3.00	2.48
Planning Lessons	2.52	2.48
Networking	2.42	2.04

*Range: 1 = low, 5 = high. The New York data are from: Dale Mann and Edward A. Shafer, "Technology and Achievement" *The American School Board Journal*, v 184, n 7, July 1997, pp 22-23 based upon a 1996 study done for the Mohawk Regional Information Center, Verona, New York by Charol Shakeshaft, Dale Mann, Robert Kottkamp, and Mike Mussi, Interactive, Inc., Huntington, New York.

Simple correlations suggest that collaborative learning and constructivist ideas were most likely to occur in the classrooms of those teachers who report the highest computer confidence level and the most time using computers in their instruction (both factors that contribute to the BS/CE Access/Attitude/Training Model).

We asked some questions to test possible negative attitudes about computers. (See Table 5.)

Table 5

Teacher Reactions to Purported Negative Effects from Computer-Related Technology*		
Purported Effect	% Disagree	% Agree
"Computers...		
...take time from direct instruction"	61	19
...make class management more difficult"	65	13
...promote frustration and aggravation"	51	20
...require more planning"	39	28
...take too much time to use"	63	11

*Mid-point, "3," responses not reported.

The most frequently chosen comment—that enhancing instruction by using computers requires more planning time—reflects the reality that adding new techniques takes time.

3.0 IMPLEMENTING BS/CE

3.1 Critical Mass

Change in schools is generally in small increments (and little interventions are easier to ignore). BS/CE was an exception, at least in part because the grade-by-grade follow-through strategy concentrated significant resources on tightly defined targets. Prior to the 1990-91 inception of BS/CE, the average school owned a total of 14 computers. If half were then used for administrative/clerical functions and two were in the library, that meant that five classrooms might have one (Apple) each. Contrast that with the arrival of four machines, a printer, networking capability, software and professional development multiplied by the number of classrooms at that year's target level—all showcased at the beginning of the school year. BS/CE was a big deal, especially for the rural schools.

3.2 Fidelity of Implementation

BS/CE was also fielded as it was designed. For school improvement in general, the most common explanation for a lack of outcomes is a lack of implementation—the training is planned but canceled, the books are purchased but not required, people are hired for one purpose and end up doing something else. That does not describe BS/CE. In the West Virginia case, the districts and the schools did use the discretion that they were accorded in software selection and in style of deployment (labs/centers versus distributed versus combined). But the major points are that not only does BS/CE have effects associated with its implementation, it was implemented.

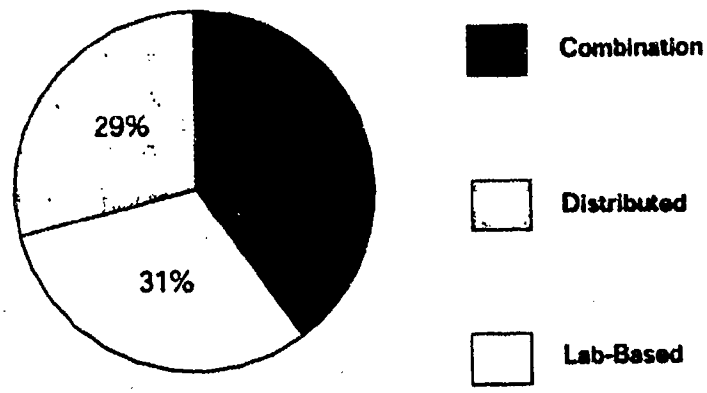
Our field work included extended visits to 18 schools. The BS/CE computers were where they were supposed to be (in classrooms or in labs/centers). When teachers were asked to describe how they used the BS/CE machines, 80% responded, "reinforcement of the standard curriculum," that is, applications tightly targeted on Basic Skills. Although there were some complaints about machines arriving before training or the unavailability of technical support, the amount of 'noise' in the West Virginia system was tiny compared to the scope and fidelity of the effort. BS/CE was fielded as it was designed.

BS/CE's implementation was more influenced by the State than is the usual practice. True, the initial design was done by a group that included teacher representation but it is also the case that teachers were required to be trained (and supported with salaries or stipends for that). True, counties could choose their software suppliers but only between IBM and Jostens and all hardware was IBM. In the final analysis, the reality of BS/CE came down to the choices of teachers behind closed classroom doors, but those classroom decisions were systematically channeled, encouraged and supported in very particular directions.

3.3 Labs/Centers versus Classroom Distribution

Schools could choose how to deploy the BS/CE computers—concentrated in labs (6 of the sampled schools, 293 students), concentrated in classrooms (5 schools, 273 students) or a combination of lab-plus-classroom distributed (7 schools, 380 students). The deployment choice is significant for policy and crucial to teachers. (See Figure 5.)

Figure 5. BS/CE Computer Deployment



Students who had access to BS/CE computers in their classrooms (the "distributed" pattern) did significantly better than students who were taught with BS/CE equipment in lab settings. The students taught in the classroom pattern had higher gains in overall scores and in math. They also scored higher on the 1998 tests than did those in labs. (There were no differences on scores by source of software.) In distributed classrooms, the BS/CE efforts account for 19% of the variance in test scores.

Teachers who had computers in the classroom reported higher skill levels in managing instruction, planning lessons, delivering instruction, and word processing.

The power of classroom integration belies the low student:computer ratios reported by teachers in schools that used labs as centers. There, 77% of the teachers reported 1:1 student:computer ratios but apparently omitted to notice that this only applies during those minutes per week that their students are assigned to the lab.

Teachers who had BS/CE computers in their classrooms (the 'distributed' pattern) reported more time using BS/CE computers for reading, math and writing instruction than either of the other two patterns. Sixty-one percent of the teachers with access to computers in their own classrooms said they were confident in using computers in their teaching compared to only 43% of the teachers who took their children to the lab for instruction in, about, or with computers.

4.0 ADDITIONAL EXPLANATIONS FOR TEST SCORE GAINS

West Virginia's experience with instructional technology is important because of the gains that can be associated with BS/CE. But the State was also changing other aspects of schooling at the same time. In understanding the significance of instructional technology, it is important to inquire into those other initiatives.

During this period, the State spent $430 million to renovate 470 school buildings. Sixty-eight new schools were built. (The state also closed 330 schools in six years, down to 840 buildings.) It is not likely that the newness of the physical plant directly impacts learning (Armor's research indicates a slight negative relation). But school attendance went up and drop-outs went down in the 1991-1997 period. It may be that a more attractive place attracts more attendance and thus increases exposure to teaching and the possibility of increased learning.

In 1989, the year the State legislature passed the BS/CE enabling legislation, West Virginia teachers were the 49th worst paid in America. In 1990, there was a statewide strike of teachers. Beginning that year, all teachers received a $5,000 pay increase[13] spread over three years: West Virginia's statewide average teacher salaries have risen 15 places among the states.

When asked to rank order three phenomena in terms of their probable effect on student learning, 48% of the teachers assigned Number One to "technology" followed by "physical school improvements" and "teacher salary increases." The teachers we studied rejected "better salaries = better teaching" as too simple an explanation for their professional enactment. It is worth noting that the achievement score gains have continued although the planned three year schedule of pay increases has long since been completed. In general, the literature on teacher compensation suggests that salary is important at two points In the career, deciding to get in and deciding to get out. But, in between, what teachers teach and how they teach it is not influenced by money. It can be influenced by things like standards, testing, supervision, peer influence and instructional technology.

Whether or not plant renovations and teacher salaries are linked to gain scores, there are compelling reasons like physical safety and the stability of the teaching force to support improvement in those things.

Beginning in 1995, West Virginia Bell Atlantic connected 700 of the State's 840 school buildings to Bell Atlantic's "World School" Internet service. The presence of all 'other technology related initiatives' in the school is related to achievement score gains but accounts for 0.4% of the difference. Those other initiatives included computers purchased from other sources, special grant programs and, in many schools, the "World School" Internet service. That capability has very probably helped, but 56% of the teachers acknowledged that they knew very little about networking and online communications and only a third of the BS/CE teachers have classroom access to the Internet.

During the years in which BS/CE has operated, the State legislature has also required local school councils, faculty senates, school-site accreditation visits and a "probation" procedure. Those activities, along with the requirement that each school have a "Unified School Improvement Plan," are similar to what other states have adopted. The policies are reasonable and even wholesome but they have not been unambiguously connected to increases in statewide test scores. There are no states (including West Virginia) in which governance modifications have been studied and have been associated with test score gains.

We have no doubt that changes in school policy, In addition to BS/CE, made some difference. The case of "standards" is instructive. The State Department of Education promulgated the "West Virginia Instructional Goals and Objectives." In order to win state contracts, both IBM and Jostens Learning correlated their software to that state framework. Once the choice between software vendors had been made, those correlation

[13] State taxes were raised $200 million in 1989 and another $200 million in 1990.

matrices became a resource if not a guide for instruction by teachers. And the teachers came to rely on them as they integrated BS/CE computers into their teaching. Simultaneously, the State reminded teachers to reinforce student basic skills acquisition through the "Teach/Re-Teach" program. The quantitative and the qualitative data both support the idea that teachers converged on using BS/CE computers to extend their Basic Skills instruction in order to position their students for the related achievement tests. Thus, the standards/assessment policies reinforced the policy of technology use integrated into the curriculum and vice versa.

Our data suggest what expert judgement supports—various policy interventions make various amounts of difference and they most probably interact.

But, we do not have direct evidence about that. In fact, few changes in schooling depend on demonstrated improvements in test scores. Text books get adopted, professional development seminars get scheduled, whole theories of learning or of school organization get implemented without any evidence that they impact test scores. That does not mean that those phenomena are not worthy or that they might not have an effect on student achievement, only that those effects—lack of effects —are not taken into account when decisions about such initiative are made. BS/CE has what others do not—measured results.

5.0 CONCLUSIONS

> "We need information to show what works and what doesn't. If we had empirical data, policy-makers would be more willing to fund technology and voters would be much more wiling to pay."
> - Lieutenant Governor Kim Robak, Nebraska (Kerry White "A Matter of Policy," *Education Week*, November 10, 1997, v. XVII, n. 11, "Technology Counts: Schools and Reform in the Information Age," p 6.)

The West Virginia legislature funded the Basic Skills/Computer Education program in hopes of levering improvements, statewide, in the school achievement of children. On the evidence of the State's change in rank relative to other states, and on the evidence of this analysis, the state's expectations were met.

And West Virginia realized additional outcomes from technology. The schools were able to try out new productivity tools, public attitudes toward schools were probably improved. Sixty-two percent of the American workforce is already "knowledge workers," people who focus on creating, organizing and communicating information[14]. BS/CE is a major part of positioning the State's children for that future.

The improvements reported here were powered by successive waves of hardware and software, the earliest generation of which reached back to the late 1980s. At BS/CE's inception, 486-megahertz machines were still on the horizon and the capital investments necessary to support broadcast-quality audio and video were still in the publishers' business plans. If we accept that these gains are a function of that previous generation of instructional technology, what will be possible next?

All jurisdictions have an obligation to reach their own conclusions about what is worth doing. The data suggest the power of instructional technology but they also signal aspects of policy strategy and tactics.

BS/CE is scalable. The expenditure totals are not out of line with other states. (See also Lewis Solmon's "Afterword.") The program's components have been well documented by the State. The outcomes are established.

[14] CEO Forum on Education and Technology, *School Technology and Readiness Report: From Pillars to Progress*, Washington DC., October 9, 1997, p 3. The figure refers to the 1994 American labor force.

Consider the logic of West Virginia's follow-through strategy. Without the yearly concentration of hardware, software and training grade-by-grade, no grade would have had a critical mass. A one or two year technology-rich effort would quickly get washed out by children falling back to successive years of technology-poor experiences. The performance of the BS/CE lead cohort has distinguished itself and the state. A follow-on program called "SUCCESS" is designed to carry the same equipment and procedures through to the upper grades. There is reason to believe that as BS/CE helped children, so will "SUCCESS;" and there is no reason to believe that there will be less technology in the lives of West Virginia's elementary and secondary students and graduates. All of that suggests that maintaining this focus will maintain these positive outcomes.

As other jurisdictions consider instructional technology as an agent of improvement, is it of interest that a defined, affordable package of hardware/software/process innovations can account for a large fraction of the test score improvement that is available to public policy intervention? And is it of further interest that, in addition to test score gains, those innovations can help position children for a technologically demanding economy, society and polity?

But, BS/CE also has a number of features that are uncommon in the state education policy landscape. The features that deliver an installed base critical mass depart from the norm of a small number of computers equitably distributed across a large number of classrooms. The choice of software from a fixed set of two vendors departs from the conventional ceding of choice among hundreds of vendors to hundreds of schools (and often, to thousands of teachers). We believe that part of the explanation for BS/CE's success is the defined focus of its implementation. It is worth noting that we did not encounter principals who complained that their traditional local autonomy was restricted and neither is there evidence of anything other than impatience as the upper grades teachers anticipated their turn on the State's hardware implementation schedule.

Still, policy choices, political choices always honor local values. In American schooling, thousands of jurisdictions make their own choices. It may be that this documentation of the student outcomes associated with West Virginia's program of Basic Skills/Computer Education will advance the consideration of similar initiatives in other jurisdictions.

Introduction

The Basic Skills/Computer Education Program (BS/CE) in West Virginia has been one of the most comprehensive (in terms of students covered in a state) and long-lived statewide education technology programs ever tried. It is one of the few programs that has been in existence long enough to provide answers to the fundamental question of whether an infusion of technology tied to the curriculum and associated professional development for teachers affect student learning as measured by improvement in scores on tests of basic skills.

Thus, the Milken Exchange commissioned Interactive, Inc[1]. to gather information on how the technology was used in West Virginia's schools and to determine if technology had any impact on the improvement in the test scores of West Virginia's students. This monograph is the report of the results of that study. The principal finding is that BS/CE worked.

Mann, Shakeshaft, Becker, and Kottkamp make this case by pointing out that about 11 percent of the total variance ($R^2 = .11$ and adjusted $R^2 = .094$) in the basic skills achievement gain scores of the 5th-grade students in their sample who have had BS/CE since 1991-92 can be explained by a model composed of factors that describe the overall BS/CE experience. In other words, about 11 percent of the gain score increase of 5th-grade students can be attributed to their participation in BS/CE. Moreover, according to the authors, since about 70 percent of the variation in test scores relates to family background, only 30 percent remains that schools can influence. Mann, Shakeshaft, Becker, and Kottkamp conclude that the 11 percent of the total variance in the basic skills achievement gain scores (from 1995-96 to 1996-97) can be explained by participation in BS/CE which is about one-third of the 30 percent variance remaining after taking into account family-related influences.

Comparing Technology with Other Policy Initiatives

These are significant findings and important evidence supporting the claims made by advocates of putting technology into all public schools and having it used properly[2]. But in order to recommend similar but more modern policies in the future it is not enough to know that BS/CE is related to test score gains; rather, we must be convinced that such policies are at least as effective as others that are of similar cost. Thus, to put Mann, Shakeshaft, Becker, and Kottkamp's findings in a context of related research, it is useful to look at effect sizes. These can be derived by dividing the increase in test scores associated with the regression coefficient for the intervention by the standard deviation of test scores in the sample. The regression coefficients and the standard deviations can be found in Mann,

[1] Interactive, Inc. is a firm whose principals, Drs. Dale Mann and Charol Shakeshaft are also professors at Teachers College, Columbia University and Hofstra University respectively.

[2] Some people believe that BS/CE is an application of old technology that should not be replicated. They call it "drill and practice" or an instructional learning system. In fact, BS/CE required new designs to meet West Virginia's needs, and did meet those needs. Although constructivist teaching and learning have merit in many situations, a variety of other applications of modern technology may be appropriate depending upon the need. In studying West Virginia's initiative, it is inevitable that Interactive, Inc. analyzed the effects associated with computer-related technology available beginning in the early 1990s. A decade is a long time in computer evolution. Observing that BS/CE made a difference for children is not the same thing as endorsing the current or future application of ten-year old hardware and software. The size of the effects documented for West Virginia is interesting especially because of the generation of hardware and software studied. Constructivist and higher order thinking skills applications, when added to the drill and practice, may well have an even greater effect.

Shakeshaft, Becker, and Kottkamp's analysis[3]. The effectiveness of an intervention is viewed as the increase in standard deviation units of test scores associated with the intervention. This approach permits comparisons of the effects of the BS/CE with other attempts to improve instruction such as class size reduction, tutoring, and the like.

Most effect size calculations begin with regression analyses in which the educational intervention is measured by a single variable—either the intervention occurred or did not. The regression coefficient for that "dummy variable" divided by the standard deviation of the outcome variable gives us a straightforward measure of the effect size. Table 1 provides a summary of some effect size studies developed by Benjamin Bloom (in *Educational Researcher*, June/July, 1984) who cites Walberg (1984).

Effect of Selected Alterable Variables on Student Achievement

		Effect Size	Percentile Equivalent
D[a]	Tutorial instruction	2.00	98
D	Reinforcement	1.20	
A	Feedback-corrective (ML)	1.00	84
D	Cues and explanations	1.00	
(A)D	Student classroom participation	1.00	
A	Student time on task	1.00[b]	
A	Improved reading/study skills	1.00	
C	Cooperative learning	.80	79
D	Homework (graded)	.80	
D	Classroom morale	.60	73
A	Initial cognitive prerequisites	.60	
C	Home environment intervention	.50[b]	69
D	Peer and cross-age remedial tutoring	.40	66
D	Homework (assigned)	.30	62
D	Higher order questions	.30	
(D)B	New science & math curricula	.30[b]	
D	Teacher expectancy	.30	
C	Peer group influence	.20	58
B	Advance organizers	.20	
	Socio-economic status (for contrast)	.25	60

[a] *Object of change process*: A-Learner; B-Instructional Material; C-Home environment or peer group; D-Teacher.
[b] Averaged or estimated from correlational data or from several effect sizes.

* Bloom, Benjamin S. "The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring." *Educational Researcher* June-July 1984: 6. This table was adapted from Walberg (1984) by Bloom.

[3] The regression coefficients are a somewhat ambiguous mixture of reciprocal influences flowing from putative cause to putative effect in unknown proportions. In short, we can't be sure of the direction of the causal influence. Does it always run from what has been arbitrarily designated as "independent variable" to "dependent variable" or is it also sometimes running in the reverse direction? For example, if we correlate children's "self-concept" and "achievement," we get a coefficient that surely reflects both self-concept raising achievement and achievement raising self-concept. This is not simply an abstract possibility in the Interactive, Inc. analysis; such variables as "Time on computer" and "Teacher attitude" could as well be causes of achievement gains as their effects. It is likely that the preponderance of the influence probably does run from putative cause to putative effect, but the other direction must be acknowledged.

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Levin, Glass, and Meister (1987) provide estimates of annual effect sizes for four educational interventions (Table 2). The effects vary by subject matter and by grade level, and of course, by the specific intervention. For example, the mean effect size for cross-age tutoring was .79 for a combined peer and adult program, .97 for the peer component and .67 for the adult component. The range was 1.02 for second-grade math to .35 for sixth-grade reading. The mean effect size for reducing class size from 35 to 30 was .06 for math and .03 for reading; reducing class size from 35 to 20 produced an effect size of .22 for math and .11 for reading. Adding an additional 30 minutes per day to instructional time had a mean effect size of .03 for math and .07 for reading. Finally, a ten-minute daily session on a mini-computer for computer-assisted instruction had a mean size effect of .12 for math and .23 for reading. Each standard deviation is approximately equal to gains of an academic year of 10 months, so each tenth of a standard deviation can be viewed as about 1 month of achievement gain per year of intervention (Levin et al, 1987).

Effect Sizes per Year of Instruction for Four Educational Interventions

	Mathematics											
Intervention	**Mean**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 5**	**Grade 6**	**Mean**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 5**	**Grade 6**
Computer-Assisted Instruction (10-minute daily session on mini-computer)												
Overall	.12c	.13a			.12b		.23c	.23b			.23b	
	Computation	.30a			.25b		Vocabulary	.25a			.25b	
	Concepts	.00a			.00b		Comprehension	.20a			.20b	
	Application	.10a			.10b							
Cross-Age Tutoring (Boise model)												
Combined peer and adult program	.79c	1.02	.91	.79	.68	.55	.42c	.50	.46	.42	.39	.35
1-Peer Component	.97a	1.02	.91				.48a	.50	.46			
1-Adult Component	.67b			.79	.68	.55	.38b			.42	.39	.35
Reducing Class Size												
From 35 to 30	.06						.03					
From 30 to 25	.07						.04					
From 25 to 20	.09						.05					
From 35-20	.22						.11					
Increasing Instructional Time (additional 30 minutes per day for each subject)	.03	.02			.04		.07	.08			.07	

Note: a = average for grades 2 and 3; b = average for grades 4, 5, and 6; c = average for grades 2 through 6.

*Levin, Henry M., Glass, G., Meister, Gail R. "Cost-Effectiveness of Computer-Assisted Instruction." *Evaluation Review* Vol. 11 No. 1, February 1987 p.57

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The Mann, Shakeshaft, Becker, and Kottkamp study differs from the ones referred to above in that the BS/CE intervention is measured not by a single independent variable, but by a set of nine components of that program (grouped into three categories), some derived from a factor analysis of responses to several survey questions. In Table 3 we divided the regression coefficients on each factor representation by the standard deviation of the test score outcome variable to get an "effect size." The quotation marks are used because these effect sizes are unusual ones—not the effect of an intervention as compared to no intervention, but rather the effect of more of the factor versus less. Moreover, regression coefficients' size depends on units of the factor, but we do not know what the units of each factor are. As an alternative, we provide the possible ranges of each variable as it is constructed to help with the interpretation. Assuming that the factor analysis converts each factor into comparable units, the effect size measures tell us the effect of having more versus less and allow us to compare effects of various aspects of the program. Most of the independent variables are scales within a relatively narrow range where a higher score means more of that attitude or input.

Calculation of Effect Sizes

	Range of Variable	Regression Coefficient	Standard Deviation of Outcome Variable	Effect Size	Standardized Beta Coefficient	Significance
Computer and BS/CE use: time spent on BS/CE and time spent using other software	3-15	1.453	16.240	0.089	0.240	0.000
Software access: choice of vendor; use of BS/CE specific software	1-2	5.958	16.240	0.367	0.184	0.000
Computer access: availability of computers to students	1-2	2.126	16.240	0.131	0.068	0.115
Other technology access: software use other than BS/CE	0-4	0.715	16.240	0.044	0.051	0.278
Student attitudes towards computers	2-4	2.742	16.240	0.169	0.099	0.025
Teacher attitudes towards computers: teacher willingness to continue learning about computers and technology	2-10	1.069	16.240	0.066	0.123	0.014
Teacher confidence: teacher comfort level and confidence in using computers	8-40	0.310	16.240	0.019	0.030	0.596
Involvement: in the planning and implementation of BS/CE	5-1	-1.959	16.240	- 0.121	- 0.097	0.065
Training: amount of time teachers spent learning on the computer on their own	1-5	1.109	16.240	0.068	0.085	0.091
Sum of all effect sizes				1.074		

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The input that can be quantified in the most meaningful way is student time[4]. The variable used combines teacher and student responses to questions on how many days per week and how many minutes per day the students work with computers at school (both time spent on BS/CE and time spent using other software). The result is a rank-order scale from 3 (15 minutes or less, one day per week in math, reading, and writing) to 15 (one hour or more, five days a week in the same three subjects). This 5th-grade computer use factor alone yields an effect size of .089.

The "basic skills/software access" factor (2 if Jostens, 1 if IBM) has an effect size of .367[5] and the "student attitudes" factor (student attitudes about importance of learning about computers compared to learning to read and write and compared to learning other subjects, range from 2 to 4) has an effect size of .169. Both of these are smaller than or equivalent to (depending on grade level and discipline) the effect sizes of cross-age tutoring cited in Levin et al, but are equal to or larger than the sizes of effects of computer-assisted instruction, class size reduction or increasing instructional time.

However, if we are really interested in the effects of the total BS/CE program, we should look at the sum of effect sizes of all its components. The point is not which individual components of the model were most effective, but rather that all the components of the model made a difference together. Assuming that there is no colinearity among the nine factors, there is some logic in simply summing the size of each of the effects[6]. When we do that the total effect size is 1.074[7]. The sum of the Mann, Shakeshaft, Becker, and Kottkamp effect sizes from these individual, unaggregated components of instructional technology are larger than those in Levin et al's 1987 report. Given the technological/ pedagogical advances since then, the gain from more recent technology is what would be expected, just as, when even more recent hardware, software and teaching practice is assessed, the effect sizes can be predicted to be larger.

The largest individual effect (.367) comes from software access. As noted above, the total effect of all significant factors is 1.074. If all factors were perfectly correlated, the overall effect would be .367. If there were no colinearity, the overall effect would be 1.074. The reality is probably somewhere between these two numbers. Given that Levin et al found mean effect sizes for computer assisted instruction of .12 for math and .23 for reading, the effect of BS/CE is perhaps at least two to five times as large. This is not surprising given that the CAI in the Levin et al study involved only a ten-minute session each day, and occurred at a much earlier stage of development of educational hardware and software.

Kulik (in Baker & O'Neil, 1994) looked at about a dozen meta analyses of studies of effectiveness of computer-based instruction. The estimates of the magnitudes of the effects ranged from .22 at the low end (18 studies conducted in elementary and secondary science courses) to .57 (18 studies in special education classes). The mean effect size was to raise test scores by .35 standard deviations, or from the 50th to the 64th percentile. As noted earlier, Levin et al found mean effect sizes of .12 and .23 for math and reading, respectively, for grades 2 through 6.

The four factors found by Mann, Shakeshaft, Becker, and Kottkamp to have statistically significant positive regression coefficients[8], and hence, relevant effect sizes were "software access," "time students spend with computers," student and teacher attitudes, and principal leadership. The first two are probably most comparable to other studies. Thus, this combined effect size of materials and time of .456 falls within the range of the Kulik survey and is higher than the effect of ten minutes per day of CAI in the Levin et al study. The .456 effect size says use of materials for more time led to an increase in test scores from the 50th to about the 67th percentile, or a 4.6-month achievement gain. This conclusion depends upon the metric on which each independent variable is measured.

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[4] Obviously, other factors can be quantified, however they may not be standard measures of equal units.

[5] There was BS/CE software and when it was used, it made a difference.

[6] There appears to be no significant correlations among the 9 independent variables. The largest is .38 between the measure of teacher control and a measure of teacher attitudes toward using computers and the BS/CE initiative. Thus the betas can be considered as additive.

[7] The coefficient on teacher leadership is negative because teacher leadership is inferred from a question about leadership of the principal. Since a higher score indicates more leadership from the principal, it means less from the teacher. Hence, this negative coefficient should be included with its sign reversed.

[8] Significance at the .02 level

Mann, Shakeshaft, Becker, and Kottkamp's result gets us to an effect size of 1.074 when we add the effects of improved student and teacher attitudes about technology and teacher training and involvement—which are engendered by BS/CE *independent* of the amount of time spent using the program's materials. If these really are independent components of BS/CE, then the program moved students from the 50th to about the 85th percentile in a year, or achieved a gain of 10.7 months over and above that which would have been expected from typical classroom instruction not aided by BS/CE.

The authors' conclusion that BS/CE had a positive effect on West Virginia appears to hold up under the scrutiny of effect size analysis. The results from West Virginia are stronger than studies of effect sizes of CAI; however, BS/CE was a project of much larger scale than most of the innovations considered elsewhere. Technology has been shown to have a positive effect. It will be left to the reader to assess how big is a move from the 50th to the 67th or 85th percentile (given our interpretation of the metric of the independent variables).

Comparing the Costs of Instructional Technology to Other Interventions

Finally, it is important to examine the improvement per dollar spent on BS/CE compared to actual or potential gains per dollar spent on other interventions. BS/CE cost $7 million per year to add technology and provide teacher training to one grade level across the state[9]. For comparison purposes, let us look at the hypothetical cost of reducing class size in West Virginia from the current level of 21 students per class to 15 students per class (Table 4). There are currently 301,314 students in K-12 and 14,348 classes and teachers (assuming one teacher per class). To reduce class size to 15 would require 5,739 additional classes and teachers. At the current average teacher salary of $33,396, the total cost of the class size reduction program would be $191,670,140 for additional teacher salaries alone. This does not include cost of adding physical classrooms, which has turned out to be a major problem for California's class size reduction effort.

	Cost of Class Size Reduction
K-12 enrollment (1997-98)*	301,314
Average teacher salary (1997-98)*	$ 33,396
Class size (1996-97)*	21
Number of classes	14,348
Number of classes if class size = 15	20,088
Additional classes & teachers needed	5,739
Cost of new teachers	$ 191,670,140
Cost per grade	$ 14,743,857
Cost in yr 2	$ 29,489,475
Cost in yr 3	$ 44,235,093
Cost in yr 4	$ 58,980,711
Cost in yr 5	$ 73,726,329
Cost in yr 6	$ 88,471,947
Cost in yr 7	$ 103,217,565

*Source: West Virginia Department of Education

[9] West Virginia Department of Education, Private Memorandum from State Superintendent of Schools, Henry R. Marockie, November 19, 1998.

If class size were reduced in one grade each year (to make such a program similar to the technology program), the cost for each additional grade would be $14,743,857. This is double the cost per grade of technology in the form of BS/CE. Moreover, not only will the cost of the new grade be incurred each year; but also, a similar cost will arise for each of the grades whose class sizes were reduced in previous years. That is, for class size reduction, the salary cost of the additional teachers comes up every year. The major costs of the technology program are incurred once, in the year the program is introduced into a grade[10].

By the time a student has completed the 5th grade, West Virginia will have spent $42 million on BS/CE or $7 million each year on the grade (K-5) that the student has entered. A class size reduction effort over the same period of time would have cost $310 million because as additional teachers are added to an additional grade level each year, the salaries of teachers added to lower grades in previous years still must be paid. A one-time expenditure of $7 million to put technology into all classrooms of a particular grade benefits children who enter that grade year after year at little additional cost (except maintenance, updating, etc.). When calculating the cost of each program per student, we must take into account that by the time the 5th-grade students reach the 5th grade, five other cohorts of kindergartners will have benefited from technology or reduced class size in kindergarten, four additional cohorts will have benefited from changes in 1st grade and so on. Thus the total cost figures presented above translate into $636 per student per year for class size reduction and $86 for BS/CE (Table 5).

[redacted] **Comparison of Costs and Benefits of Reducing Class Size and BS/CE**

One Year Effect Sizes		Effect size of reducing class size from 35 to 30 on math scores	Effect size of reducing class size from 35 to 20 on math scores	Effect size of reducing class size from 21 to 15 on math scores	Effect size of "materials" aspect of technology program	Effect size of time students spend with technology	Effect size of "materials" aspect of technology program	Effect size of time students spend with technology
i		0.06	0.22	0.096	0.367	0.089	0.367	0.089
E.S. PER 5 ST DECR FROM 30-20			0.08					
Months gain				0.96	3.67	0.89	3.67	0.89
				Cost in each year	Cost $7m per year	Cost $7m per year	Cost $7m per year plus 25% maintenance	Cost $7m per year plus 25% maintenance
Spending yr 1				$14,743,857	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Spending yr 2				$29,487,714	$7,000,000	$7,000,000	$8,750,000	$8,750,000
Spending yr 3				$44,231,571	$7,000,000	$7,000,000	$10,500,000	$10,500,000
Spending yr 4				$58,975,428	$7,000,000	$7,000,000	$12,250,000	$12,250,000
Spending yr 5				$73,719,285	$7,000,000	$7,000,000	$14,000,000	$14,000,000
Spending yr 6				$88,463,142	$7,000,000	$7,000,000	$15,750,000	$15,750,000
Amount spent by the time a student finishes 5th grade				$309,620,997	$42,000,000	$42,000,000	$68,250,000	$68,250,000
Students		301,314	Cum students					
St per grade	K	23,178	23,342					
	1	23,178	46,356					
	2	23,178	69,534					
	3	23,178	92,712					
	4	23,178	115,890					
	5	23,178	139,068					
			486,902					
Amount spent per st per yr				$635.90	$86.26	$86.26	$140.17	$140.17
$ per 1 mo gain in math scores in 5th grade				$662.40	$23.50	$96.92	$38.19	$157.50

[10] Later we show the impact of annual maintenance and upgrading costs of technology.

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These per student costs now have to be related to test score gains. Levin et al estimate the effect size of reducing class size from 35 to 30 as .06 and from 35 to 20 as .22. Taking account of the apparent greater effect (per reduction of 5 students) when class size is reduced from 30 to 20 than when the reduction is from 35 to 30, and recognizing that the reduction suggested for West Virginia is six students, we estimate roughly that, based on the Levin et al study, the effect size of class size reduction in West Virginia would be .096. This compares with effect sizes of .367 for the materials aspect of technology and .089 for time students spend with technology. Each .1 effect size reflects a one-month gain in grade level due to the intervention. Thus, a one-month gain from reducing class size from 21 to 15 would cost $662 and a similar improvement would cost $97 using BS/CE if we consider only the effect of time spent with technology by students. The effect of materials implies that a one-month gain costs $23.50[11].

So far, we have assumed a one-time cost for each additional year of BS/CE. Usually a technology program requires annual expenditures for maintenance, upgrading of hardware and software and ongoing teacher training. Thus we recalculated the costs of BS/CE to include an expenditure of 25% of implementation costs in each year after implementation (Table 5). This cost increase raises the cost of obtaining a one month gain in test scores in the 5th grade from $23.50 to $38.19 for software access and from $96 to $157.50 for time students spend with technology. These costs are still several times less than the costs of achieving the same test score growth by class size reduction.

These estimates are rather crude, and are based upon a number of assumptions. The differences between the two reforms we compared are very large. Thus, if our assumptions are too favorable to the intervention with technology, reasonable but less favorable assumptions are likely still to show greater cost-effectiveness for technology than for class size reduction. However, they lead us to conclude that not only is there a statistically significant relationship between BS/CE and test score gains; and not only can these gains be translated into effect sizes comparable to those of other interventions, but also, the gains from programs that update BS/CE's positive features can be achieved at a much lower cost than could similar gains from a currently very popular alternative intervention, namely, class size reduction.

Lewis C. Solmon

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11 We are using Levin's figures on math scores whereas in West Virginia we are looking at a test of basic skills that is a specific Stanford/West Virginia product and includes math, reading, and language arts. Implicitly we are assuming that each area can be improved equally with a particular treatment.

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Testing On Computers: A Follow-up Study Comparing Performance On Computer and On Paper

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Abstract

Russell and Haney (1997) reported that open-ended test items administered on paper may underestimate the achievement of students accustomed to writing on computers. This study builds on Russell and Haney's work by examining the effect of taking open-ended tests on computers and on paper for students with different levels of computer skill. Using items from the Massachusetts Comprehensive Assessment System (MCAS) and the National Assessment of Educational Progress (NAEP), this study focuses on language arts, science and math tests administered to eighth grade students. In addition, information on students' prior computer use and keyboarding speed was collected. Unlike the previous study that found large effects for open-ended writing and science items, this study reports mixed results. For the science test, performance on computers had a positive group effect. For the two language arts tests, an overall group effect was not found. However, for students whose keyboarding speed is at least 0.5 or one-half of a standard deviation above the mean, performing the language arts test on computer had a moderate positive effect. Conversely, for students whose keyboarding speed was 0.5 standard deviations below the mean, performing the tests on computer had a substantial negative effect. For the math test, performing the test on computer had an overall negative effect, but this effect became less pronounced as keyboarding speed increased. Implications are discussed in terms of testing policies and future research.

Introduction

Recently, Walt Haney and I (Russell & Haney, 1997) reported that open-ended tests administered on paper to students accustomed to working on computer may seriously underestimate students' achievement. Although previous research on multiple-choice items suggests that the mode of administration, that is paper versus computer administration, does not significantly affect the test taker's performance (Bunderson, Inouye & Olsen, 1989), our study suggests that the mode of administration may have an extraordinarily large effect on students' performance on open-ended items.

Focusing on students participating in a project that placed heavy emphasis on computers, the study indicates that approximately 60% of the students in the Advanced Learning Laboratory (ALL School) were performing adequately on writing tests before the project began. Nearly two years after the program was implemented the same writing tests taken on paper indicated that only 30% of the students were writing adequately, an apparent decline of approximately 30% points. Yet, when the same tests were administered on computer (without student access to word processing tools such as spell checking or grammar checking), nearly 70% of students performed adequately. This significant and startling difference also occurred on National Assessment of Educational Progress (NAEP) reading and science items, which required students to respond to open-ended items (similar to items used in the Third International Math and Science Study, the Massachusetts Comprehensive Assessment System and other state level testing programs). The study concludes that for the students in the ALL School, most of whom are accustomed to working on computers, open-ended test questions administered on paper severely underestimated students' achievement.

Although our findings raise questions about the validity of open-ended test results for students accustomed to working on computer but who completed tests on paper, our study had several shortcomings. As we noted, only one extended writing item was used. Furthermore, no information regarding the extent to which students used computers or the proficiency with which students used computers was available. All of the examinees included in the study were accustomed to working on computers. Thus it was not possible to study the mode of administration effect across varied levels of previous computer use. Finally, beyond scores for a set of open-ended items performed by both groups on paper, no other information about prior academic achievement, such as standardized test scores or grades, was considered.

Despite these shortcomings, the results raise important questions about the extent to which scores for open-ended items administered on paper can be used to make inferences about individual students (or their schools) who are accustomed to working on computers. Moreover, if test scores are used to evaluate the effect increased expenditures for computers have on student achievement, the use of open-ended items administered on paper may also undermine the growing emphasis on educational technology.

In this study, I build on our prior work and overcome the shortcomings of our previous study. Specifically, I improved the study design in five ways. First, the sample of students was broadened to cover a range of prior computer experience. Second, information about students' prior use of computers, preference for writing on computer or on paper, and an indicator of students' keyboarding skill was collected. Third, rather than focusing on one extended writing task, several items were administered. Fourth, rather than focusing specifically on writing, open-ended math, language arts, and science items were examined. And fifth, all items included in this study had been used in state or national testing programs and had been validated previously. Thus, for this study I analyze the effect of computer administration across levels of computer use/proficiency using several open-ended items in the areas of language arts, math, and science. Specifically, the following research questions are addressed:

1. Does the effect reported by Russell and Haney (1997) hold across levels of computer

use/proficiency?

2. Does the mode of administration effect occur within and across subject areas and if so, is the magnitude of the effect consistent across subject areas?
3. Do students who prefer to write on paper perform better than predicted on open-ended items administered on paper and do students who prefer to write on computer perform better than predicted on open-ended items administered on computer?

Background

For three decades, educational theorists have proposed many ways in which computers might influence education. Although it was not until the 1970's that computers began having a presence in schools, since then the use of computers in education has increased dramatically (Zandvliet & Farragher, 1997). The National Center for Education Statistics reports that the percentage of students in grades 1 to 8 using computers in school more than doubled from 31.5 in 1984 to 68.9 in 1993 (Snyder & Hoffman, 1990; 1994). Similarly, the availability of computers to students in school increased from one computer for every 125 students in 1983 to one computer for every 9 students in 1995 (Glennan & Melmed, 1996). As the number of computers has increased, theories about how computers might benefit students' writing have proliferated. To a lesser extent, some researchers have carried out formal studies to examine whether writing on computer actually leads to better writing. Many of these studies have reported that writing on computers leads to measurable increases in students' motivation to write, the quantity of their work and the number of revisions made. Some of these studies also indicate that writing on computers improved the quality of writing. In a meta-analysis of 32 computer writing studies, Bangert-Drowns (1993) reports that about two-thirds of the studies indicated improved quality for text produced on computer. However, the extent to which writing on computers leads to higher quality writing seems to be related to the type of students examined. Generally, improvements in the quality of writing produced on a computer are found for learning disabled students, early elementary students, low-achieving students and college-aged students. Differences generally are not found for middle school and high school students.

Learning Disabled, Early Elementary Students and College-Aged Students

Although neither Kerchner and Kistinger (1984) nor Sitko and Crealock (1986) included a comparison group in their studies, both noted significant increases in motivation, quantity and quality of work produced by learning disabled students when they began writing on the computer. After teaching learning disabled students strategies for revising opinion essays, MacArthur and Graham (1987) reported gains in the number of revisions made on computer and the proportion of those revisions that affected the meaning of the passage. They also noted that essays produced on computer were longer and of higher quality. In a separate study, MacArthur again reported that when writing on a computer, learning disabled students tended to write and revise more (1988). At the first grade level, Phoenix and Hannan (1984) report similar differences in the quality of writing produced on computer.

Williamson and Pence (1989) found that the quality of writing produced by college freshman increased when produced on computer. Also focusing on college age students, Robinson-Stavely and Cooper (1990) report that sentence length and complexity increased when a group of remedial students produced text on the computer. Hass and Hayes (1986a) also found that experienced writers produced papers of greater length and quality on computer as compared to those who created them on paper.

Middle and High School Students

In a study of non-learning disabled middle school students, Dauite (1986) reported that although writing performed on the computer was longer and contained fewer mechanical errors, the overall quality of the writing was not better than that generated on paper. In a similar study, Vacc (1987) found that students who worked on the computer spent more time writing, wrote more and revised more, but that holistic ratings of the quality of their writing did not differ from text produced with paper-and-pencil.

At the middle school level, Grejda (1992) did not find any difference in the quality of text produced on the two mediums. Although Etchison (1989) found that text produced on computer tended to be longer, there was no noticeable difference in quality. Nichols (1996) also found that text produced on computer by sixth graders tended to be longer, but was not any better in quality than text produced on paper. Yet, for a group of eighth grade students, Owston (1991) found that compositions created on computer were rated significantly higher than those produced on paper.

Focusing on high school freshman, Kurth (1987) reports that there was no significant difference in the length of text produced on computer or on paper. Hawisher (1986) and Hawisher and Fortune (1989) also found no significant differences in the quality of writing produced by teenagers on paper and on computer. Hannafin and Dalton (1987) also found that for high achieving students, writing on computer did not lead to better quality writing. But for low-achieving students, texts produced on the computer were of a higher quality than those produced on paper.

Summary of Studies

The research summarized above suggests many ways in which writing on computer may help students produce better work. Most formal studies report that when students write on computer they tend to produce more text and make more revisions. Studies that compare student work produced on computer with work produced on paper find that for some groups of students, writing on computer also has a positive effect on the quality of student writing. This positive effect is strongest for students with learning disabilities, early elementary- aged students and college-aged students. All of the studies described above focus on student work produced in class under un-timed conditions. These studies also focus on work typically produced for English or Language Arts class, such as short stories or essays. However, the study presented here focuses on writing produced under formal timed testing conditions in three subject areas, namely language arts, math and science. Specifically, this study addresses the extent to which producing open-ended responses on computer or on paper effects students' performance, particularly for students with different levels of computer use.

Study Design

To better understand whether open-ended test items administered on paper underestimate the achievement of students accustomed to working on computers, six open-ended math, six science, and six language arts items were converted to a computer format and then administered in two modes, paper and computer. In addition, all students completed a computer use survey and performed a short keyboarding test. Finally, an indicator of prior achievement, namely Grade 7 Stanford Achievement Test version 9 (SAT 9) scores, was collected for each student. As is explained in detail below, the indicator of achievement was used to stratify and randomly assign representative sample groups and is used as a covariate for some analyses.

The study focuses on three subject areas: math, language arts, and science. For each subject area, a total of six open-ended items were administered. To decrease the amount of testing time required for each student, students were divided into four groups. Two of these four groups performed the six science items and three of the language arts items, only. For ease of reference I call these groups of students SL and LS. The remaining two groups of students performed the six math items and the other three language arts items, only. These groups of students are referred to as ML and LM. All students completed the computer use survey and performed the keyboarding test. In addition, an indicator of prior achievement was collected for each student.

The study occurred in three stages. During stage 1, SAT 9 scores were collected for each student. In total, four SAT 9 scores were collected for each student: Comprehensive Normal Curve Equivalent (NCE), Math NCE, Language Arts NCE and Science NCE. Once collected, the Comprehensive NCE was used to stratify and randomly assign four groups of students. Two of these groups formed the SL and LS students while the remaining two groups formed the ML and LM students.

During stage 2, all students completed the computer use survey and performed the keyboarding test. During stage 3, a crossed design was used to administer the open-ended items to each group. In this crossed design, the SL students first performed the science items on computer and then performed three language arts items on paper. The LS students first performed the three language arts items on computer and then performed the science items on paper. Similarly, the ML students first performed the math items on computer and then performed the three language arts items on paper. Finally, the LM students first performed the language arts items on computer and then performed the math items on paper. Below, the instruments, sampling method and scoring method are discussed in greater detail.

Instruments

The instruments used in this study fall into three categories: indicators of prior achievement; computer experience; and open-ended tests.

Indicator of Prior Achievement

As described in greater detail below, an indicator of prior achievement was used to assign students to experimental groups and as a covariate during analyses. Since the sample of students was limited to students in grade eight, the students' grade 7 SAT 9 NCE scores were used as the indicator of prior achievement.

Computer Experience

Two instruments were used to estimate students' level of computer experience. First, a survey that focused on prior computer use was administered to all students. Second, all students completed a brief keyboarding test administered on computer.

Student Questionnaire

The survey was designed to collect information about how much experience students had working with computers and, in particular, how they used computers during their writing process. The survey included questions that asked:

1. how long the student has had a computer in his/her home:
2. how many years they have used a computer;
3. how often they currently use a computer in school and at home;
4. how often they use a computer during different stages of their writing process (e.g., brainstorming, outlining, composing a first draft, editing, writing the final draft); and
5. whether they prefer to write papers on paper or on computer.

In addition, the survey asked students to draw a picture of their writing process and to then describe what they had drawn. The purpose of the drawing prompt was to collect information about if and when computers enter the student's writing process. Finally, the student questionnaire asked students to indicate their gender and their race/ethnicity.

To code student drawings, the following guide was used:

- 0 - No computer visible
- 1 - Computer used for final draft only
- 2 - Computer used prior to creating the final draft

When coding drawings, both the drawing and the student's description of their drawing were reviewed prior to assigning a score. All drawings were coded by one rater. However, to examine inter-rater reliability, a sample of 20 drawings was coded by a second rater. For these 20 drawings, there was no discrepancy between the two raters' scores.

Keyboarding Test

To measure keyboarding skills, all students performed a computer based keyboarding test. The keyboarding test contained two passages which students had two minutes apiece to type verbatim into the computer. Words per minute unadjusted for errors was averaged across the two passages and was used to estimate students' keyboarding speed. Both keyboarding passages were taken directly from encyclopedia articles to assure that the reading level was not too difficult.

Although there is considerable debate about how to quantify keyboarding ability (see West, 1968, 1983; Russon & Wanous, 1973; Arnold, et al, 1997; and Robinson, et al, 1979), for the purposes of this study, students average words per minute (WPM) uncorrected for errors was recorded. In each of the scoring guidelines used to rate student responses to the open-ended test items, spelling was not explicitly listed as a criterion raters should consider when scoring student responses. For this reason, students keyboarding errors did not seem to be directly relevant to this study.

Open-Ended Tests

This study examines the mode of administration effect on student performance in three subject areas: science, math, and language arts. To restrict testing time to 60 minutes per test, 6 science items, 6 math items and two sets of 3 language arts items were administered. All items included in this study were taken directly from open-ended test instruments used previously. Sources for items include the National Assessment of Educational Progress (NAEP) and the Massachusetts Comprehensive Assessment System (MCAS).

Language Arts Items

In total, six language arts items were used in this study. Three of the language arts items were taken from the 1999 Spring administration of MCAS. Two of the items were taken directly from the 1988 Grade 8 NAEP Writing Assessment. And the final language arts item was taken from the 1992 Grade 8 NAEP Writing Assessment.

The three MCAS language arts items focus on reading comprehension. For each of these items, students read a brief passage and then answers an open-ended question about the passage. The passages include a poem titled "The Caged Bird", a speech titled "Sojourner Truth's Speech From the 1850s", and a short story titled "The Lion's Share".

The three NAEP language arts items focus on writing. The first writing item asks students to create a narrative piece that describes an embarrassing experience they have had. The second writing item prompt focuses on creative writing and asks students to write a good, scary ghost story. The final writing item tests students' expository writing skills and asks students to write about their favorite story, telling why they like it and what it means to them.

When selecting the items, two criteria were used. First, the time required to respond to the item could not exceed 30 minutes. Second, the amount of reading (if any) students had to complete before responding to the item could not exceed 1 page. The reason for this second criterion was to maximize the amount of time students spent actually responding to the item. It should be noted that all three MCAS items required students to read a short body of text before responding to a question while none of the NAEP items required students to read any text. For this reason, the MCAS items can be classified as primarily measuring reading comprehension and the NAEP items can be classified as measuring writing ability.

After the six items were selected, they were placed into one of two booklets. Two MCAS items and the 1992 NAEP item formed the test booklet titled Language Arts 1. The remaining MCAS item and the two 1988 NAEP items formed the second test booklet titled Language Arts 2.

Mathematics

The mathematics test booklet contained six items. Three of the items were taken from the 1998 grade 8 spring MCAS test and three items were taken from the 1996 grade 8 NAEP Assessment. Two of the math items tested fractions and proportions. Two items focused on students' ability to read and interpret a graph. One item tested students' ability to calculate and interpret means and medians. And the final item focused on students' problem solving skills.

When selecting mathematics items, two criteria were applied. First, the item had to require students to generate an extended (a minimum of one sentence) written response. Second, the item could not require students to draw a picture, diagram or graph. The first criterion was used to assure that students had to compose text in order to perform well on the item. The second criterion was used to prevent students working on computer from having to access drawing or graphing programs.

Science

Like the mathematics items, three of the science items came from the 1998 grade 8 spring MCAS test and three items came from the 1996 grade 8 NAEP assessment. Similarly, all of the items required students to generate a substantial amount of text (more than a sentence) in order to succeed and none of the items required students to draw pictures or graphs. Two of the items tested students understanding of the physical sciences. Two items focused on human biology. One item tested students understanding of electricity. And the final item tested students' ability to design an experiment.

Scoring Criteria

For all of the items, the scoring criteria developed by MCAS or NAEP were used.

All of the MCAS scoring guidelines used a scale that ranged from 0 to 4. For the MCAS items, a score of 0 indicated that the item was left blank or that the student's response was completely incorrect. Scores of 1 to 4 represented increasingly higher levels of performance.

The scales for the NAEP scoring guidelines varied from 1-3, 1-4, 1-5, and 1-6. A code of 9 was awarded to items that were left blank. For all items, a 1 indicated that the student's response was completely incorrect. Scores of 2 to 6 represented increasingly higher levels of performance. To make the scores for the MCAS and the NAEP items more comparable, all blank responses were re-coded as a zero. The resulting NAEP scales ranged from 0-3, 0-4, 0-5, or 0-6.

Converting Paper Versions to Computer Versions

Before the tests could be administered on computer, the paper versions were converted to a computerized format. Several studies suggest that slight changes in the appearance of an item can affect performance on that item. Something as simple as changing the font in which a question is written, the order items are presented, or the order of response options can affect performance on that item (Beaton & Zwick, 1990; Cizek, 1991). Other studies have shown that people become more fatigued when reading text on a computer screen than when they read the same text on paper (Mourant, Lakshmanan & Chantadisai, 1981). One study (Haas & Hayes, 1986b) found that when dealing with passages that covered more than one page, computer administration yielded lower scores than paper-and-pencil administration, apparently due to the difficulty of reading extended text on screen. Clearly, by converting items from paper to computer, the appearance of items is altered.

To minimize such effects, students taking a test on computer were given a hard copy of the test booklet. The only difference between the hard copy of the test booklets received by students taking the test on computer and the original paper version was that the blank lines on which students recorded their responses were replaced by instructions to write answers on the computer.

Prior to beginning a test, students in the computer group launched a computer program that performed four tasks. First, the program prompted students to record their name and identification number. Second, the program presented the same directions that appeared in their hard copy. Third, the program allowed students to navigate between text boxes in which they recorded their responses to the open-ended questions presented in their test booklet. Finally, after a student completed the test, the program presented two questions about the taking the test on computer (described more fully below).

To assist students in recording their responses in the proper text box, the program placed the question number and accompanying prompt above each text box. To help avoid confusion, only one text box appeared on the screen at a time. To move between text boxes, two buttons appeared on the bottom of the screen. The button labeled "Next" allowed students to navigate to the text box for the next question and the button labeled "Back" allowed students to move to the previous question. Below the last text box, a button labeled "I'm Finished" appeared. Once students felt they were finished with the test, they clicked on the "I'm Finished" button. To assure that they were in fact finished, students were asked again if they were done. If so, they clicked the "I'm Finished" button again. Otherwise, they clicked the "Back" button to continue working on their responses.

When students were finished taking the test and had selected the "I'm Finished" button twice, they were prompted with two questions about the test. The first asked students: "Do you think you would have done better on this test if you took it on paper. Why?" The second question asked: "Besides not knowing the answer to a question, what problems did you have while taking this test on computer?" Students were required to answer these questions before they could quit the program.

To create a computerized version of the test booklets, the following steps were taken:

1. An appropriate authoring tool, namely Macromedia Director, was selected to create software that would allow students to navigate between questions and to write data to a text file.
2. A data file was created to store student input, including name, ID number, and responses to each item.
3. A prototype of each test was created, integrating the text and database into a seamless application. As described earlier, navigational buttons were placed along the lower edge of the screen. In addition, a "cover" page was created in which students entered their name and id numbers.
4. The prototype was tested on a class of ninth grade students to assure that all navigational buttons functioned properly, that data was stored accurately, and that items were easy to read.
5. Finally, the prototype was revised as needed and the final versions of the computer tests were installed on twenty computers in the ALL School and twenty- four computers in the Sullivan Middle School.

For all questions, examinees used a keyboard to type their answers into text boxes that appeared on the screen. To enable students to write as much as they desired, scrolling text boxes were used for all items. Although they could edit using the keyboard and mouse, examinees did not have access to word processing tools such as spell-checker or grammar-checker.

Sampling Method

The sample of students was drawn from two Worcester Public Middle Schools, namely The Advanced Learning Laboratory (ALL School) and the Sullivan Middle School. Since the analyses focus on how the mode of administration effect varies across achievement levels and, more importantly, computer use/proficiency levels, the population of students was pooled across the two schools. Before sampling began, a list of all grade eight students in the ALL School and all grade eight students from one team in the Sullivan Middle School was generated. In total, this yielded 327 students. For each student on the list, an indicator of prior achievement, namely grade 7 SAT 9 scores, was collected. Since some of the students were new to the district or had not taken the SAT 9 the previous year, SAT 9 scores were only available for 287 students. Using a stratified random assignment procedure, students were then assigned to one of two groups. Group 1 was then assigned to the Language Arts 1 and Math tests and group 2 was assigned to the Science and Language Arts 2 tests. For each group, this process was repeated again, this time assigning half of the students in group 1 to take the Language Arts 1 test on computer first and the remaining half to take the Math test on computer first. Similarly, half of the second group of students was assigned to take the Language Arts 2 test on computer first and the remaining half took the Science test on computer first.

Those students for whom SAT 9 scores were not available were randomly assigned to one of the four groups. Although their scores are not included in the analyses below, their responses were used to train raters prior to scoring the test booklets for students included in the analyses.

Due to absences and refusals to perform one or more instruments, complete data records were available for 229 students. To be clear, a complete data record was defined as one containing a student's SAT 9 scores, their responses to the student questionnaire, the results of the keyboarding test, and results from at least one of the open-ended tests.

Scoring

To reduce the influence hand writing has on raters' scores (Powers, Fowles, Farnum & Ramsey, 1994), all responses to the open-ended items administered on paper were transcribed verbatim into computer text. The transcribed responses were randomly intermixed with the computer responses. All student responses were formatted with the same font, font size, line spacing and line width. In this way, the influence mode of response might have on the scoring process was eliminated.

Scoring guidelines designed for each item were used to score student responses. To increase the accuracy of the resulting scores, all responses were double-scored. When discrepancies between raters' scores arose, an adjudicator awarded the final score. At the conclusion of the scoring process, one score was recorded for each student response.

To estimate inter-rater reliability, the original scores from both raters were used. The resulting scores were compared both via correlation and percent agreement methods. Table 1 shows that for most items the correlation between the two raters' scores was above .8 and for many items the correlation was above .9. For two of the items on the first language arts test, however, correlations were closer to .7. Nonetheless, this represents an adequate level of inter-rater reliability.

Table 1
Inter-rater Reliability for Open-Ended Items

	Correlation	% Exact Agreement	% Within 1 Point
Language Arts 1			
Item 1	.80	.68	1.00
Item 2	.74	.50	1.00
Item 3	.72	.59	.95
Language Arts 2			
Item 1	.95	.84	1.00
Item 2	.94	.88	1.00
Item 3	.91	.76	1.00
Math			
Item 1	.91	.60	1.00
Item 2	.83	.65	.90
Item 3	.88	.80	.95
Item 4	.94	.80	1.00
Item 5	.84	.90	1.00
Item 6	.70	.75	.95
Item 1	.80	.64	.95
Item 2	.86	.73	1.00
Item 3	.88	.82	1.00
Item 4	.88	.86	1.00
Item 5	.92	.82	1.00
Item 6	.85	.73	1.00

To estimate intra-rater reliability, one rater double-scored 20% of the responses. The resulting scores for this rater were compared via correlation and percent agreement methods. Table 2 shows high correlations between the two sets of scores. Moreover, where discrepancies occurred, the difference between the two scores was never more than one point.

Table 2
Intra-rater Reliability for Open-Ended Items

	Correlation	% Exact Agreement	% Within 1 Point
Language Arts 1			
Item 1	.92	.86	1.00

Item 2	.95	.95	1.00
Item 3	.88	.77	1.00
Language Arts 2			
Item 1	.91	.82	1.00
Item 2	.93	.91	1.00
Item 3	.94	.86	1.00
Math			
Item 1	.92	.77	1.00
Item 2	.97	.91	1.00
Item 3	.98	.95	1.00
Item 4	.96	.82	1.00
Item 5	.88	.91	1.00
Item 6	.84	.82	1.00
Science			
Item 1	.94	.86	1.00
Item 2	.96	.91	1.00
Item 3	.93	.91	1.00
Item 4	.92	.91	1.00
Item 5	.98	.95	1.00
Item 6	.94	.86	1.00

Note that the adjudicated scores were produced for all students and that the adjudicated scores were used for all analyses described below.

Results

This study explores the relationships between prior computer use and performance on four open-ended test booklets. To examine this relationship, three types of analyses were performed. First, independent samples t-tests were employed to compare group performance. Second, total group regression analyses were performed to estimate the mode of administration effect controlling for differences in prior achievement. And third, sub-group regression analyses were performed to examine the group effect at different levels of keyboarding speed. However, before the results of these analyses are described, summary statistics are presented.

Summary Statistics

Summary statistics are presented for each of the instruments included in this study. The raw data are also available from this point. These original data are presented by the author for othes who may wish to perform secondary data analyses; anyone publishing analyses of these data should cite this article as the original source. For the student questionnaire, keyboarding test, and the SAT 9 scores, summary statistics are based on all 229 students included in the study. For the language arts, math and science open-ended tests, summary statistics are based on the sub-set of students that performed each test. When between group analyses are presented, summary statistics for select variables are presented for each sub-set of students that performed a given test.

Keyboarding Test

The keyboarding test contained two passages. Table 3 shows that the mean number of words typed for passage 1 and passage 2 was 31.2 and 35.0, respectively. As described above, the number of words typed for each passage was summed and divided by 4 to yield the number of words typed per minute for each student. Across all 229 students included in this study, the mean WPM was 16.5. Considering that the minimum WPM required by most employers when hiring a secretary is at least 40, an average of 16.5 WPM suggests that most students included in this study were novice keyboarders.

Table 3
Summary Statistics for the Keyboarding Test

N=229	Mean	Std Dev	Min	Max
Passage 1	31.2	11.2	5	71
Passage 2	35.0	10.6	9	80
WPM	16.5	5.3	4.8	37.8

Student Questionnaire

The student questionnaire contained 11 questions. The maximum score for the Survey was 46 and the minimum score was 10. The scale for each item varied from 0 to 2, 1 to 2, 1 to 3 and 1 to 6. To aid in interpreting the summary statistics presented in table 4, the scale for each item is also listed. In addition to the Survey total score, summary statistics are presented for the Comp-Writing sub-score.

Although comparative data is not available, Table 4 suggests that on average students included in this study do not have a great deal of experience working with computers. The average student reports using a computer for between two and three years, having had a computer in the home for less than a year, and using a computer in school and in their home less than 1-2 hours a week. Furthermore, most students report that they do not use a computer when brainstorming, creating an outline or writing a first draft. Slightly more students report using a computer to edit the first draft. Most students, however, report using a computer at least sometimes to write the final draft. Similarly, most students indicate that if given the choice, they would prefer to write a paper on computer than on paper. Yet, when asked to draw a picture of their writing process, less than half the students included a computer in their drawing.

Again, the divergence between students' preference and their reported use of a computer in the writing process may indicate that when recording their preference some students provided a socially desirable response. If students did provide socially desirable responses, estimating the effect preference had on students' performance will be less precise.

Table 4
Summary Statistics for the Student Quesitonnaire

N=229	Scale	Mean	Std Dev	Min	Max

Years having computer at home	1-6	2.81	1.86	1	6
Years using computer	1-6	4.75	1.51	1	6
Use computer in school	1-6	2.74	1.10	1	6
Use computer at home	1-6	2.75		1	6
Brainstorm with computer	1-3	1.35	.55	1	3
Outline with computer	1-3	1.50	.57	1	3
First draft with computer	1-3	1.72	.75	1	3
Edit with computer	1-3	1.85	.73	1	3
Final draft with computer	1-3	2.50	.65	1	3
Preference	1-2	1.80	.40	1	2
Computer in drawing	0-2	.59	.72	0	2
Survey	10-43	24.37	5.68	12	41
Comp-Writing	5-17	9.51	2.77	5	17

Indicator of Prior Achievement

Four indicators of prior achievement were collected prior to the study. Specifically, SAT 9 Composite, Reading, Math and Science NCE scores were collected for each student. Note that the NCE scores provided for this study had been multiplied by 10 before they were supplied by the district office. Thus, the range for the NCE scores was 10 to 990 with a mean of 500 and a standard deviation of approximately 210 (see Crocker and Algina, 1986 for a fuller description of NCE scores). Table 5 displays the mean and standard deviation for each SAT 9 score. The mean score for each subject area and for the composite score for students included in this study is approximately .5 standard deviations below the national average. However, within this sample of students there is a substantial variation.

Table 5
Summary Statistics for Indicators of Prior Achievement

N=229	Mean	Std Dev	Min	Max
Composite NCE	402	150.2	119	888
Reading NCE	391	178	10	990
Math NCE	389	174	10	990
Science NCE	434	172	67	896

Open-Ended Tests

Four open-ended tests were administered in three subject areas: math, science and language arts. As is described more fully above, two versions of the language arts test were administered. Each of the tests was administered to a sample of students. The number of students who performed each test ranged from a high of 117 for Language Arts 1 to a low of 100 for Language Arts 2. Within each sample, approximately half of the students performed the test on computer and half of the students performed the test on paper.

The summary statistics for the total sample of students who performed each test are presented in tables 6 through 9. Since each test contained some items from NAEP and some items from MCAS, it is not possible to directly compare the total test scores to the performance of students in other settings. However, to aid in interpreting the test scores, summary statistics are presented for each item along with the national or state average performance for each item. Note that comparison data for the MCAS items represents the mean score on a 0-4 point scale for all students in the state. Comparison data for the NAEP items represents the percentage of students nationally performing adequately or better on the item.

Table 6 presents the summary statistics for Language Arts 1 and Table 7 presents the summary statistics for Language Arts 2. For all items but one item included in the language arts tests, a score below 3 indicates inadequate performance. For item 2 on language arts test 1, a score below 4 indicates inadequate performance. For all items, many students failed to perform adequately. For all items, the mean performance was below 3 and for four items the mean performance was below 2. This low level of performance suggests these items were difficult for these samples of students.

Table 6
Summary Statistics for Language Arts 1

N=117	Scale	Mean	Std Dev	% Adequate*	Mean on MCAS	% Adequate on NAEP
Item 1	0-4	1.42	1.04	19	1.99	NA
Item 2	0-4	1.50	1.05	16	1.73	NA
Item 3	0-6	2.91	1.41	31	NA	29
Total	0-14	5.84	2.85			

* For items 1 and 2, a score of 3 or higher was considered adequate performance.
For item 3, a score of 4 or higher was considered adequate performance.

Table 7
Summary Statistics for Language Arts 2

N=100	Scale	Mean	Std Dev	% Adequate*	Mean on MCAS	% Adequate on NAEP
Item 1	0-4	1.23	0.98	10	1.74	NA
Item 2	0-4	1.67	1.07	31	NA	51
Item 3	0-4	2.12	0.81	22	NA	25
Total	0-12	5.02	2.29			

* For all three items, a score of 3 or higher was considered adequate performance.

Table 8 displays the summary statistics for the Math test. Again, for all items except number 4, a score below 3 indicates inadequate performance. For item 4, a score below 4 indicates inadequate performance. For all items, the mean performance for this sample of students indicates that on average students performed below the adequate level.

Table 8
Summary Statistics for Math

N=110	Scale	Mean	Std Dev	% Adequate*	Mean on MCAS	% Adequate on NAEP
Item 1	0-4	1.18	1.17	15	2.05	NA
Item 2	0-4	1.26	1.23	18	1.83	NA
Item 3	0-4	1.64	1.03	22	1.84	NA
Item 4	0-5	2.45	1.28	33	NA	28
Item 5	0-3	1.44	.53	2	NA	11
Item 6	0-4	1.99	.89	30	NA	26
Total	0-24	9.96	4.18			

* For items 1, 2, 3 and 6, a score of 3 or higher was considered adequate.
For item 4, a score of 4 or higher was considered adequate.
For item 5, a score of 3 was considered adequate.

Table 9 displays the summary statistics for the Science test. For all items, a score below 3 indicates inadequate performance. For all items, the mean performance was below the adequate level.

Table 9
Summary Statistics for Science

N=102	Scale	Mean	Std Dev	% Adequate*	Mean on MCAS	% Adequate on NAEP
Item 1	0-4	1.89	1.02	32	1.49	NA
Item 2	0-4	1.71	1.21	26	1.70	NA
Item 3	0-3	1.50	.75	8	NA	19
Item 4	0-3	1.21	.67	3	NA	9
Item 5	0-3	1.78	.90	22	NA	52
Item 6	0-4	1.57	1.09	20	1.81	NA
Total	0-24	9.66	4.14			

* For all items, a score of 3 or higher was considered adequate performance.

Clearly, students had difficulty with all four of these tests. For all MCAS items, this sample of students performed at a level below that of other students in the state of Massachusetts. For the NAEP items, students performed about as well or worse than other students in the nation.

Comparing Performance on Computer and on Paper

For each test, approximately one half of the sample of students was randomly assigned to perform the test on computer while the other half performed the test on paper. Tables 10 through 13 present the results of between group comparisons for each test. For each test, an independent samples t-test (assuming equal variances for the two samples and hence using a pooled variance estimate) was performed for the total test score. The null hypothesis for each of these tests was that the mean performance of the computer and the paper groups did not differ from each other. Thus, these analyses test whether performance on computer had a statistically significant effect on students' test scores.

To examine whether prior achievement, computer use or keyboarding skills differed between the two groups of students who performed each test, independent samples t-tests were also performed for students' SAT 9 Composite score, the corresponding SAT 9 sub-test score, Survey, Comp-Writing and WPM. The results of these tests are also presented in tables 10 through 13.

Table 10 shows that on average students who performed the first language arts test on paper performed the same as students who performed the test on computer. Similarly, differences between the two groups' SAT 9 Comprehensive scores, SAT 9 Reading scores, Survey scores, and WPM were not statistically significant. However, Table 10 shows that the mean Comp-Writing score for students who performed the language arts 1 test on computer was larger than the mean for students who performed the test on computer.

Table 10
Between Group Comparisons for Language Arts 1

Paper N = 57 Computer N = 60	Mean	Std Dev	SE of Mean	t-value	Sig.
LA 1					
Paper	5.84	2.65	.35		
Computer	5.83	3.04	.39	.02	.99
SAT 9 Comp.					
Paper	379	145	19		
Computer	421	159	21	-1.49	.14
SAT 9 Reading					
Paper	360	168	22		
Computer	426	189	24	-1.98	.05
Survey					
Paper	24.6	5.6	.75		
Computer	23.9	5.9	.76	.67	.51

Comp-Writing					
Paper	10.1	2.8	.37		
Computer	9.0	2.6	.33	2.09	.04*
WPM					
Paper	17.5	4.3	.56		
Computer	16.4	5.3	.68	1.17	.24

*Significant at the .05 level.

On the second language arts test, table 11 shows that Comp-Writing was the only measure on which the two groups differed. However, for the second language arts test, students who performed the test on computer had higher Comp-Writing scores on average than did those students who performed the test on paper. For all other instruments, the two groups did not differ significantly.

Table 11
Between Group Comparisons for Language Arts 2

Paper N = 45 Computer N = 55	Mean	Std Dev	SE of Mean	t-value	Sig.
LA 2					
Paper	5.07	1.70	.25		
Computer	4.98	2.70	.36	.18	.86
SAT 9 Comp.					
Paper	413	138	20		
Computer	393	146	19	.59	.55
SAT 9 Reading					
Paper	402	173	26		
Computer	376	172	23	.74	.46
Survey					
Paper	24.4	5.8	.87		
Computer	25.1	5.7	.76	-.63	.53

Comp-Writing					
Paper	8.9	3.1	.46		
Computer	10.1	2.6	.36	-2.09	.04*
WPM					
Paper	15.7	4.9	.73		
Computer	17.2	6.5	.88	-1.23	.22

*Significant at the .05 level.

With a few exceptions, the students who performed the first language arts test also performed the math test. However, those students who performed the first language arts test on computer performed the math test on paper and vice versa. For this reason, table 12 indicates that the mean Comp-Writing score for the computer group was higher than that of the paper group. Again, this difference is statistically significant. For all other instruments, Table 12 indicates that differences between the two groups' scores were not statistically significant.

Table 12
Between Group Comparisons for Math

Paper N = 54 Computer N = 56	Mean	Std Dev	SE of Mean	t-value	Sig.
Math					
Paper	10.70	4.34	.59		
Computer	9.25	3.90	.52	1.84	.07
SAT 9 Comp.					
Paper	414	155	21		
Computer	407	154	21	.23	.82
SAT 9 Math					
Paper	401	179	24		
Computer	406	190	25	-.16	.87
Survey					
Paper	23.6	5.98	.81		

Computer	25.1	5.72	.76	-1.29	.20
Comp-Writing					
Paper	9.0	2.66	.36		
Computer	10.1	2.65	.35	-2.22	.03*
WPM					
Paper	16.0	4.7	.64		
Computer	17.9	5.2	.69	-2.01	.05

*Significant at the .05 level.

The open-ended science test was the only test for which there was a statistically significant difference in the two groups' test performance. Table 13 shows that on average the computer group performed better than the paper group. There were no other statistically significant differences between the two groups.

Table 13
Between Group Comparisons for Science

Paper N = 51 Computer N = 51	Mean	Std Dev	SE of Mean	t-value	Sig.
Science					
Paper	8.55	3.88	.54		
Computer	10.76	4.14	.58	-2.79	.006*
SAT 9 Comp.					
Paper	388	134	19		
Computer	426	152	21	-1.33	.19
SAT 9 Science					
Paper	414	154	21		
Computer	466	181	25	-1.57	.12
Survey					
Paper	25.4	5.5	.77		

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Computer	24.0	5.7	.80	1.22	.23
Comp-Writing					
Paper	9.9	2.6	.37		
Computer	9.1	3.0	.43	1.39	.17
WPM					
Paper	17.1	6.3	.88		
Computer	15.9	5.1	.72	1.01	.32

*Significant at the .05 level.

Note that statistical significance for the t-tests reported above was not adjusted to account for multiple comparisons. Given that six comparisons were made for each group, there is an increased probability that reported differences occurred by chance. Employing the Dunn approach to multiple comparisons (see Glass & Hopkins, 1984), α for c multiple comparisons, α_{pc}, is related to simple α for a single comparison as follows:

$$\alpha_{pc} = 1 - (1 - \alpha)^{1/c}$$

Hence, for six comparisons the adjusted value of a simple 0.05 alpha level becomes 0.009. Analogously, a simple alpha level of 0.01 for a simple comparison becomes 0.001.

Once the level of significance is adjusted for multiple comparisons, the open-ended science test is the only instrument for which there is a statistically significant group difference. This difference represents an effect size of .57 (Glass's delta effect size was employed). Although this effect size is about half of that reported by Russell and Haney (1997), it suggests that while half of the students in the computer group scored above 10.76, approximately 30% of students performing the test on paper scored above 10.76. The difference between the two groups' open-ended science scores, however, may be due in part to differences in their prior achievement as measured by SAT 9 Science scores.

To control for differences in prior achievement, a multiple regression was performed for each open-ended test. Tables 14 through 17 present the results of each test score regressed on the corresponding SAT 9 score and group membership. For all four regression analyses, the regression coefficient (B) for group membership indicates the effect group membership has on students' performance when the effect of SAT 9 scores is controlled. Group membership was coded 0 for the paper group and 1 for the computer group. A positive regression coefficient indicates that performing the test on computer has a positive effect on students' test performance. A negative regression coefficient suggests that on average students who performed the test on computer scored lower than students who performed the test on paper.

Table 14 indicates that SAT 9 Reading scores are a significant predictor of students' scores on the first open-ended language arts test. For each one standard score unit increase in SAT 9 Reading scores, on average students experience a .42 standard score increase in their test score. Table 14 also indicates that after controlling for differences in SAT 9 Reading scores, performing the first language arts test on computer has a negative impact on students scores. This effect, however, is not statistically significant.*

Table 14
Language Arts 1 Regressed on SAT 9 Reading and Group Membership

	B	SE B	Beta	T	Signif.
SAT 9 Reading	.007	.001	.42	4.87	<.0001
Group	-.443	.492	-.08	-.90	.37
F	11.85				<.0001
N	117				
R^2	.17				
Adjusted R^2	.16				

The results for the second language arts test are similar to those for the first language arts test. Table 15 shows that a one point standard score increase in SAT 9 Reading score is associated with a .4 point standard score increase in language arts 2 score and that this effect is statistically significant. Controlling for SAT 9 Reading scores, group membership does not have a significant effect on students' test score.

Table 15
Language Arts 2 Regressed on SAT 9 Reading and Group Membership

	B	SE B	Beta	T	Signif.
SAT 9 Reading	.005	.001	.40	4.3	<.0001
Group	.051	.428	.01	.1	.91
F	9.12				.0002
N	100				
R^2	.16				
Adjusted R^2	.14				

For both the math and science tests, SAT 9 scores and group membership have statistically significant effects on students' scores. The direction of the effect, however, is different for each test. Table 16 indicates that performing the open-ended math test on computer has a negative effect on students' test scores when SAT 9 Math scores are controlled. For science, this effect is reversed. Table 17 shows that after controlling for differences in SAT 9 Science scores, performing the open-ended science test on computer leads to higher scores than performing the same test on paper. For both tests, the effects are equivalent to just less than .2 standard score units.

Table 16
Math Regressed on SAT 9 Math and Group Membership

	B	SE B	Beta	T	Signif.
SAT 9 Math	.016	.001	.72	11.03	<.0001
Group	-1.546	.541	-.19	-2.86	.005

F	64.41				<.0001
N	110				
R^2	.54				
Adjusted R^2	.54				

Table 17
Science Regressed on SAT 9 Science and Group Membership

	B	SE B	Beta	T	Signif.
SAT 9 Science	0.014	.002	.59	7.50	<.0001
Group	1.466	.645	.18	2.28	.025
F	34.19				<.0001
N	102				
R^2	.41				
Adjusted R^2	.40				

Sub-Group Analyses

The regression analyses presented above indicate that mode of administration did not have a significant effect on students' performance on either language arts test. For the science test, performing the test on computer had a positive effect on students' scores. And for the math test, performing the test on computer led to lower performance. For all four of these analyses, the effect was examined across levels of computer use. To test whether the effect of mode of administration varied for students with different levels of computer skill, students' WPM was used to form three groups. The first group contained students whose WPM was .5 standard deviations below the mean, or less than 13.8. The second group contained students whose WPM was between .5 standard deviations below the mean and .5 standard deviations above the mean, or between 13.8 and 19.2. The third group contained students whose WPM was .5 standard deviations above the mean or greater than 19.2. For each group, the open-ended test scores were regressed on SAT 9 scores and group membership.

Table 18 displays the results of the three separate regressions for the first language arts test. For students whose WPM is .5 standard deviations below the mean and for students whose WPM is within .5 standard deviations of the mean, performing the test on computer has a negative effect on their scores. However, for these two groups of students, neither SAT 9 Reading nor group membership is a statistically significant predictor of language arts 1 score. However, for students whose keyboarding speed is one-half of standard deviation above the mean, or greater than 19.2 words per minute, performing the test on computer has a statistically significant positive effect on their performance. This effect is also three times stronger than the relationship between their SAT 9 reading score and their performance on the first language arts test. For the first language arts test, performing the test on computer seems to hurt students whose WPM is near or well below the mean and helps students whose WPM is well above the mean.

Table 18
Language Arts 1 Regressed on SAT 9 Reading and Group for Three Sub-Groups

WPM <13.8 N=30					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	0.006	0.003	.36	1.98	.06
Group	-1.115	1.001	-.20	-1.12	.27
Adjusted R^2	.08				
13.8<WPM<19.2 N=54					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	0.004	.002	.23	1.66	.10
Group	-1.330	.694	-.27	-1.91	.06
Adjusted R^2	.05				
WPM >19.2 N=33					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	.003	.002	.19	1.32	.20
Group	2.946	.764	.56	3.86	.0006
Adjusted R^2	.38				

The same relationship was found for the second language arts test (Table 19). However, for this test, the negative effect of taking the test on computer was statistically significant for students whose WPM was .5 standard deviations below the mean. For students whose WPM was within .5 standard deviations of the mean, performing the test on computer also had a negative effect on test performance, but this effect was not statistically significant. For students whose WPM was .5 standard deviations above the mean, performing the test on computer had a positive effect of nearly a half standard score on their language arts 2 test scores. This effect was statistically significant.

Table 19
Language Arts 2 Regressed on SAT 9 Reading and Group for Three Sub-Groups

WPM <13.8 N=35					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	-.0001	.002	-.02	-.10	.92
Group	-1.48	.601	-.41	-2.47	.02
Adjusted R^2	.11				

13.8<WPM >19.2 N=37					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	.002	.002	.17	1.02	.31
Group	-.974	.631	-.26	-1.54	.13
Adjusted R^2	.08				
WPM >19.2 N=28					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	.006	.002	.37	2.32	.03
Group	2.068	.71	.46	2.90	.008
Adjusted R^2	.43				

For the open-ended math test, performing the test on computer had a negative effect on students' scores at all levels of keyboarding (Table 20). However, as keyboarding speed increased, this effect became less pronounced. For students whose WPM was .5 standard deviations below the mean, taking the test on computer had an effect of -.39 standard score units. For students whose WPM was within .5 standard deviations of the mean, this effect was -.24 standard score units. Both of these effects were statistically significant. However, for students whose WPM was .5 standard deviations above the mean, the effect was -.17 standard units and was not statistically significant.

Table 20
Math Regressed on SAT 9 Math and Group for Three Sub-Groups

WPM <13.8 N=30					
	B	SE B	Beta	T	Signif.
SAT 9 Math	.015	.003	.68	5.58	<.0001
Group	-3.068	.970	-.39	-3.16	.004
Adjusted R^2	.57				
13.8<WPM >19.2 N=49					
	B	SE B	Beta	T	Signif.
SAT 9 Math	.010	.003	.50	4.09	.0002
Group	-1.55	.796	-.24	-1.96	.05
Adjusted R^2	.30				

WPM >19.2 N=31					
	B	SE B	Beta	T	Signif.
SAT 9 Math	.019	.003	.73	5.96	<.0001
Group	-1.499	1.070	-.17	-1.40	.17
Adjusted R^2	.56				

Conversely, taking the science test on computer had a positive effect on students' scores at all levels of keyboarding speed (Table 21). However, this effect was only statistically significant for students whose WPM was within .5 standard deviations of the mean. For students whose WPM was .5 standard deviation units above the mean, this effect is less pronounced and is not statistically significant.

Table 21
Science Regressed on SAT 9 Science and Group for Three Sub-Groups

WPM <13.8 N=35					
	B	SE B	Beta	T	Signif.
SAT 9 Science	.011	.003	.50	3.33	.002
Group	.909	1.020	.13	.89	.38
Adjusted R^2	.24				
13.8<WPM >19.2 N=40					
	B	SE B	Beta	T	Signif.
SAT 9 Science	.010	.002	.47	4.00	.0003
Group	3.368	.893	.45	3.77	.0006
Adjusted R^2	.48				
WPM >19.2 N=27					
	B	SE B	Beta	T	Signif.
SAT 9 Science	.021	.004	.70	4.71	.0001
Group	.170	1.204	.02	.14	.89
Adjusted R^2	.45				

Discussion

The experiment described here extends the work of Russell and Haney (1997) and improved upon their study in five ways. First, this study included students whose prior computer experience varied more broadly. Second, many more open-ended items in the area of language arts, math and science were administered. Third, all of the open-ended test items included in this study had been used in state or national testing programs and had been validated previously. Fourth, an indicator of academic achievement was collected prior to the study and was used both to randomly assign students to groups and as a covariate during regression analyses. And fifth, information on students' prior computer use and keyboarding speed was collected and used during analyses.

In their study, Russell and Haney (1997) reported large, positive group differences which were consistent for all writing, math and science open-ended items administered on computer. In this study, a significant positive group difference was found only for the open-ended science test. This effect was about half the size reported by Russell and Haney (1997). However, in this study students' level of prior computer use varied more than it did in the previous study. Although Russell and Haney did not collect a formal measure of computer use, the students included in their study were so accustomed to working on computer that when standardized tests were given, the school had difficulty finding enough pencils for all students. Although three years have passed since the previous study, it may be possible to estimate the difference in the level of prior computer use of the students included in both studies.

This study includes students from two schools, one of which was the focus of the previous study. Table 22 compares the WPM and survey scores for students in the ALL School and Sullivan Middle School. For both measures of computer use and for keyboarding speed, students in the ALL School have significantly higher scores. For the ALL School the mean WPM was nearly .5 standard deviations above the mean for the total sample while the mean for students from the Sullivan Middle School was below the total sample mean. By including Sullivan Middle School students in this study, a broader range and lower levels of computer use were represented. Including students with low levels of computer use and poor keyboarding skills seems to have counteracted the effect described in the previous study since these students performed less well on the language arts computer tests than on the paper tests.

Table 22
Comparison of Computer Use across Participating Schools

ALL N = 35 Sullivan N = 194	Mean	Std Dev	SE of Mean	t-value	Sig.
WPM					
ALL	18.9	5.1	.36		
Sullivan	16.1	6.2	1.05	2.94	.004
Survey					
ALL	27.5	5.8	.99		
Sullivan	23.8	5.5	.39	3.69	<.0001
Comp-Writing					
ALL	11.1	2.6	.43		

Sullivan	9.2	2.7	.20	3.84	<.0001

To examine the effect the mode of administration had on student performance at different levels of computer use, sub-group analyses were performed. Figure 1 summarizes the effects found for three sub-groups: a. students whose WPM was .5 standard deviations below the mean; b. students whose WPM was within .5 standard deviations of the mean; and c. students whose WPM was .5 standard deviations above the mean.

Figure 1 Effect of Performing Test on Computer When Prior Achievement is Controlled

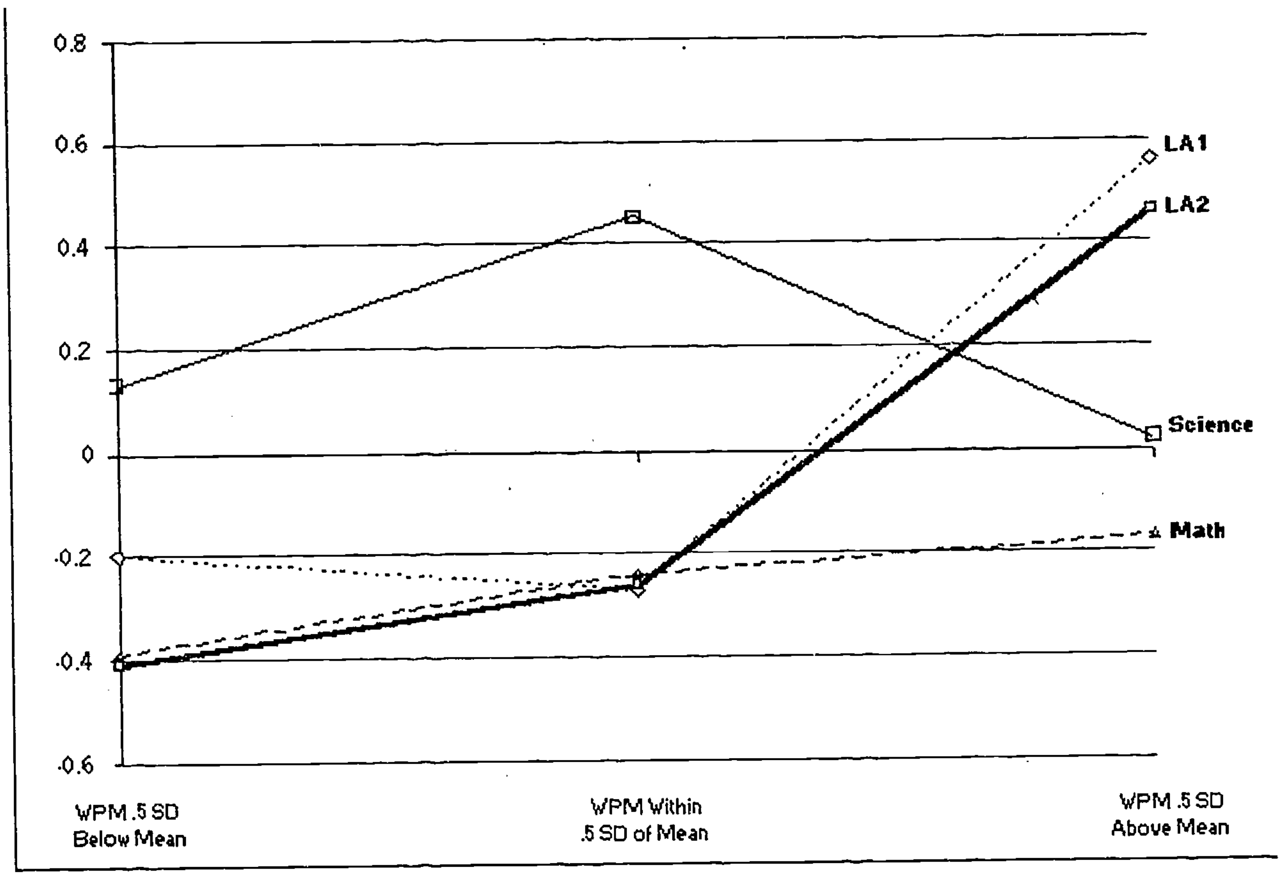


Figure 1 shows that across three of the four tests, performing the test on computer had an adverse effect on the performance of students whose WPM was .5 standard deviations below the mean. Conversely, for students whose WPM was at least .5 standard deviations above the mean, performing the language arts tests on computer had a moderate positive effect. While performing the math test on computer had a negative effect for all students, this negative effect became less pronounced as students' keyboarding speed increased. For the Science test, performing the test on computer had a positive effect across levels of computer use. However, the effect was much larger for students whose WPM was within .5 standard deviations of the mean than it was for students whose keyboarding speed was either .5 standard deviations above the mean or .5 standard deviations below the mean.

Explaining the Effects

To explore the reasons why some students had difficulty working on computers, students were asked to answer the following two questions after they completed the computer version of the test: 1. Do you think you would have done better on this test if you took it on paper? Why?; and 2. Besides not knowing the answer to a question, what problems did you have while taking this test on computer?

Students' responses to these questions were coded in two ways. First, the following numerical code was used:

- 0 - No, I would not perform better on paper
- 1 - I would perform the same or it didn't matter
- 2 - Yes, I would perform better on paper

In addition to these codes, an emergent coding scheme was used to tabulate the reasons students provided for their answers. While coding responses to the post-test questions, it became apparent that when read together, the two questions provided more information about students' experience than reading them separately. Some students would simply write yes or no for the first question, but their reasoning became apparent in their response to the second question. Other students explained the problems they encountered for the first question and wrote little for the second question. For this reason, responses to both questions were read during the emergent coding.

Table 23 presents the numerical codings for the first question. Across all tests, only 10% of students indicated that they would have performed better if they had taken the test on paper. However, over half of those who indicated they would have performed better on paper took the math test on computer. To explore why more students who took the math test on computer felt they would perform better on paper, the full responses to the two follow-up questions were examined.

Table 23
Frequency of Students Responses to Post-Test Question 1: Do you think you would have done better on this test if you took it on paper?

	Frequency	Percent
Language Arts 1		
Not better on paper	38	63.3
Same on paper	19	31.7
Better on paper	3	5.0
Language Arts 2		
Not better on paper	36	65.5
Same on paper	15	27.3
Better on paper	4	7.3
Math		
Not better on paper	20	35.7
Same on paper	18	32.1
Better on paper	18	32.1
Science		
Not better on paper	32	62.7

Same on paper	16	31.4
Better on paper	3	5.9

Table 24 presents the frequency of student responses by test. Clearly, the most frequently sited problem related to students' keyboarding skills.* Across all tests, about 25% of the students who performed the test on computer indicated they had difficulty "finding the keys," "pressing the wrong key" or simply said they "couldn't type." Twenty percent of the students who performed the math test on computer also complained that it was difficult to show their work on the computer or that they had to solve problems on paper and then transfer it to the computer. Several students who performed the language arts tests on computer mentioned that they preferred the computer because it was neater and that they didn't have to erase mistakes but could simply delete them. Across all tests, a few students also stated that they preferred the computer because their hands did not get as tired or that it was faster to write on the computer.

Table 24
Frequency of Responses to Post-test Questions 1 and 2

	LA 1	LA 2	Math	Science	Total
Difficulty typing	12	12	17	18	59
Neater on computer/can delete	8	9	2	2	21
Can't show work/drawings			10		10
Ran out of time on computer	1	2	3	1	7
Hand doesn't get tired	3	1	2	1	7
Faster on computer	3	1	2	1	7
Can take notes/solve problems on paper	1		4		5
Think better on computer/concentrate better	2	1	1	1	5
Write easier on paper			1	2	3
Hard looking back and forth between paper and computer			2		2
Hard to read screen			2		2
Problems with mouse		1	1		2
Easier to concentrate on paper	1	1			2
Write Poorly on paper				1	1
More comfortable on paper		1			1
More space on paper		1			1
Became confused where to put answers			1		1

Examining these responses, it appears that many more students who took the language arts tests recognized the computer's ability to display text that is easy to read and edit as an advantage. Conversely, students who took the math test felt that the inability to present and manipulate numbers in text was a disadvantage. In part, these different reactions to performing the tests on computer may explain the negative group effect for the math test and the positive group effects for the language arts tests. However, students' responses provide little insight into the overall group effect for science.

The Effect of WPM on Student Performance

To further examine the relationship between level of computer use and students' performance on the language arts tests, separate regression analyses were performed for students who performed the tests on paper and those who performed the tests on computer. For each of these regression analyses, the effect of prior computer use on students' performance was estimated controlling for SAT 9 scores. To provide separate estimates for keyboarding speed and for students' survey scores, two sets of regressions were performed for each sub- group. First, the test score was regressed on SAT 9 score, WPM and Survey. Second, the test score was regressed on SAT 9 score, WPM and Comp-Writing. Since Survey is partially composed of Comp-Writing, effects for each variable are estimated through separate regressions to avoid redundancy in the data and hence decrease the effects of colinearity. Figures 2 through 5 display the effects each variable had on test performance for students who took the test on computer and for those who took the test on paper.

Figure 2 and 3 show that across all tests, WPM is a weak predictor of students' scores when the test is performed on paper. However, for both language arts tests and the science test, WPM is a good predictor of students' scores when the test is performed on computer. This suggests that when these tests are performed on computer, the speed with which a student can type had a significant effect on their performance. However, for the math test, the effect of WPM on students' performance on computer is much less pronounced.

Figure 2: Effect of WPM on Student Performance Controlling for Survey

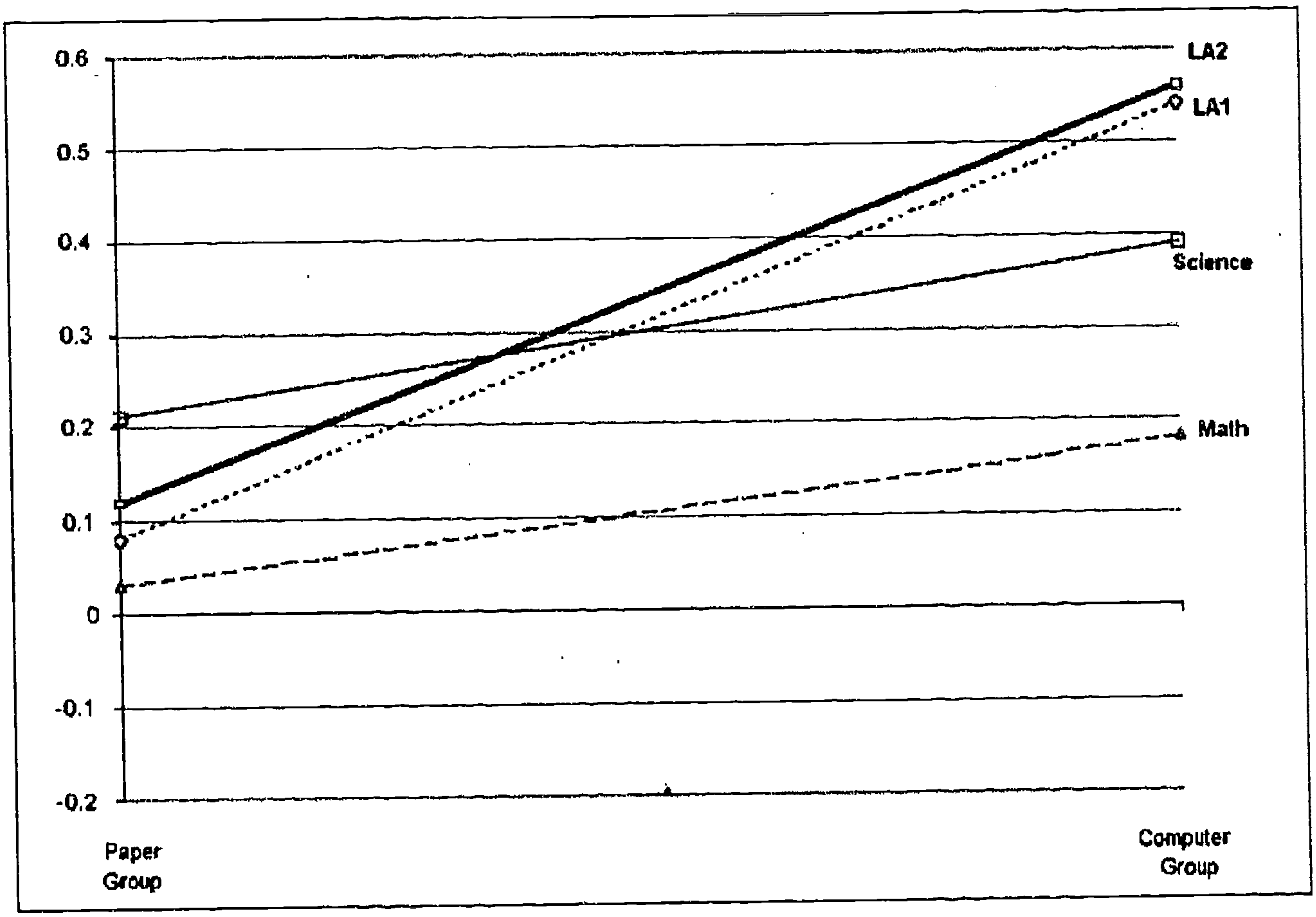
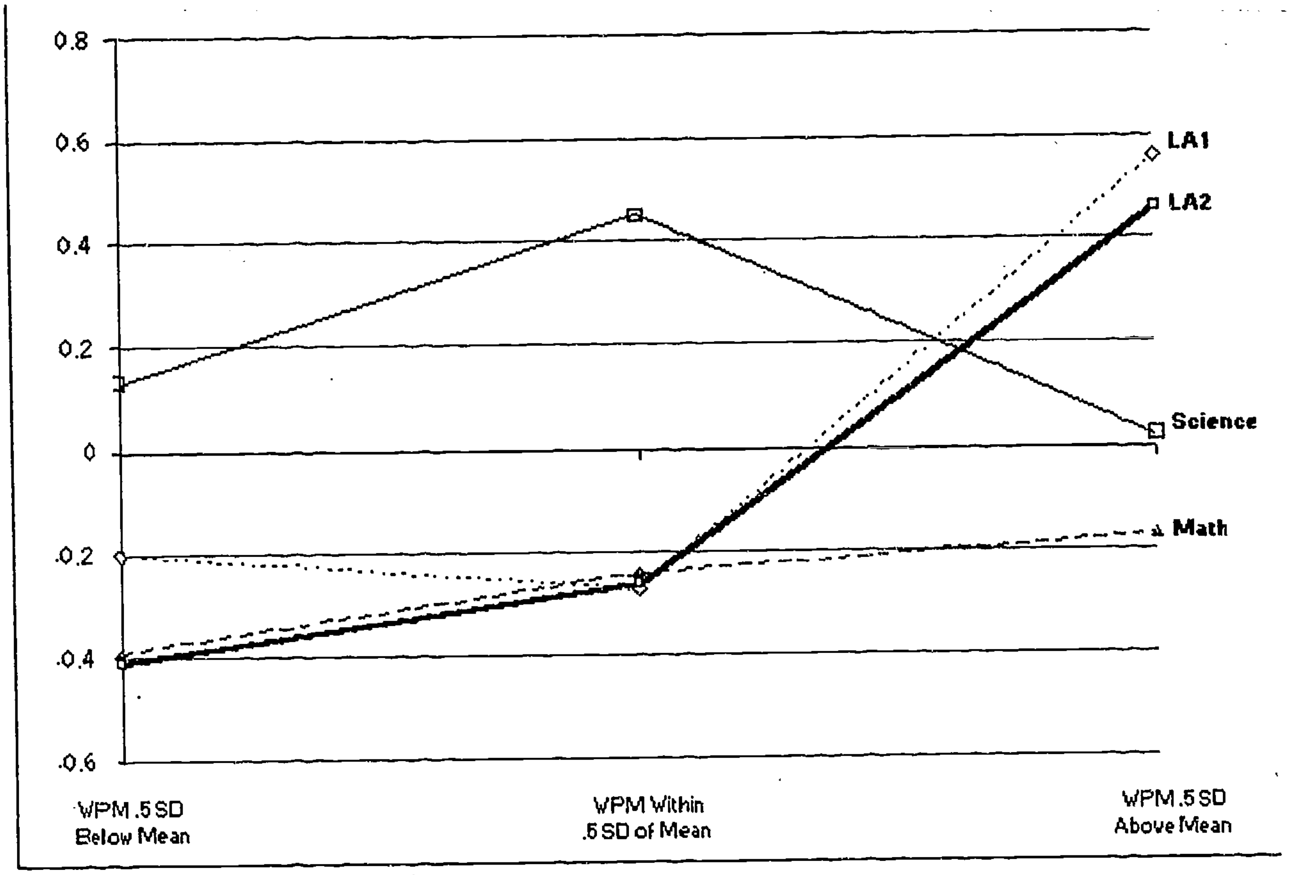


Figure 3: Effect of WPM on Student Performance Controlling for Comp-Writing



Figures 4 and 5 indicate that neither the total Survey score nor the Comp- Writing score had a meaningful effect on the performance of students in either group. In fact, when the effect of WPM is considered, both the amount of prior computer use and use of computers during the writing process have slightly lower effects when the test is taken on computer for the language arts and science tests. Yet, for the math test, the effect is larger and positive. This pattern is difficult to explain. Nonetheless, the weak relationship between either Survey or Comp-Writing and students' performance on computer suggests that students' level of computer use is not as important as their keyboarding proficiency in predicting their performance on open-ended tests. In future studies it is highly recommended that measures of keyboarding speed rather than self-reported levels of computer use are collected and used to examine effects of computer and paper administration.

Figure 4: Effect of Survey on Student Performance Controlling for WPM

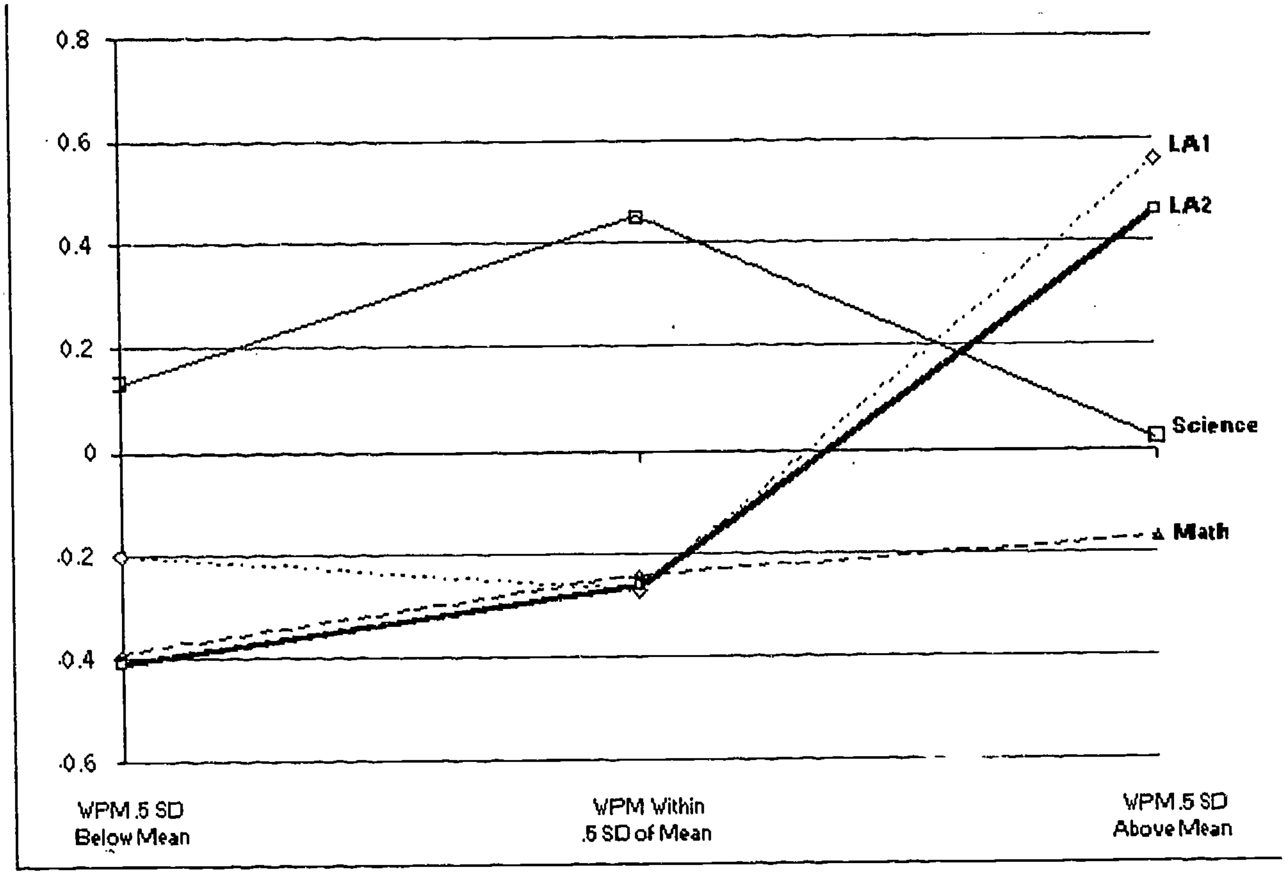
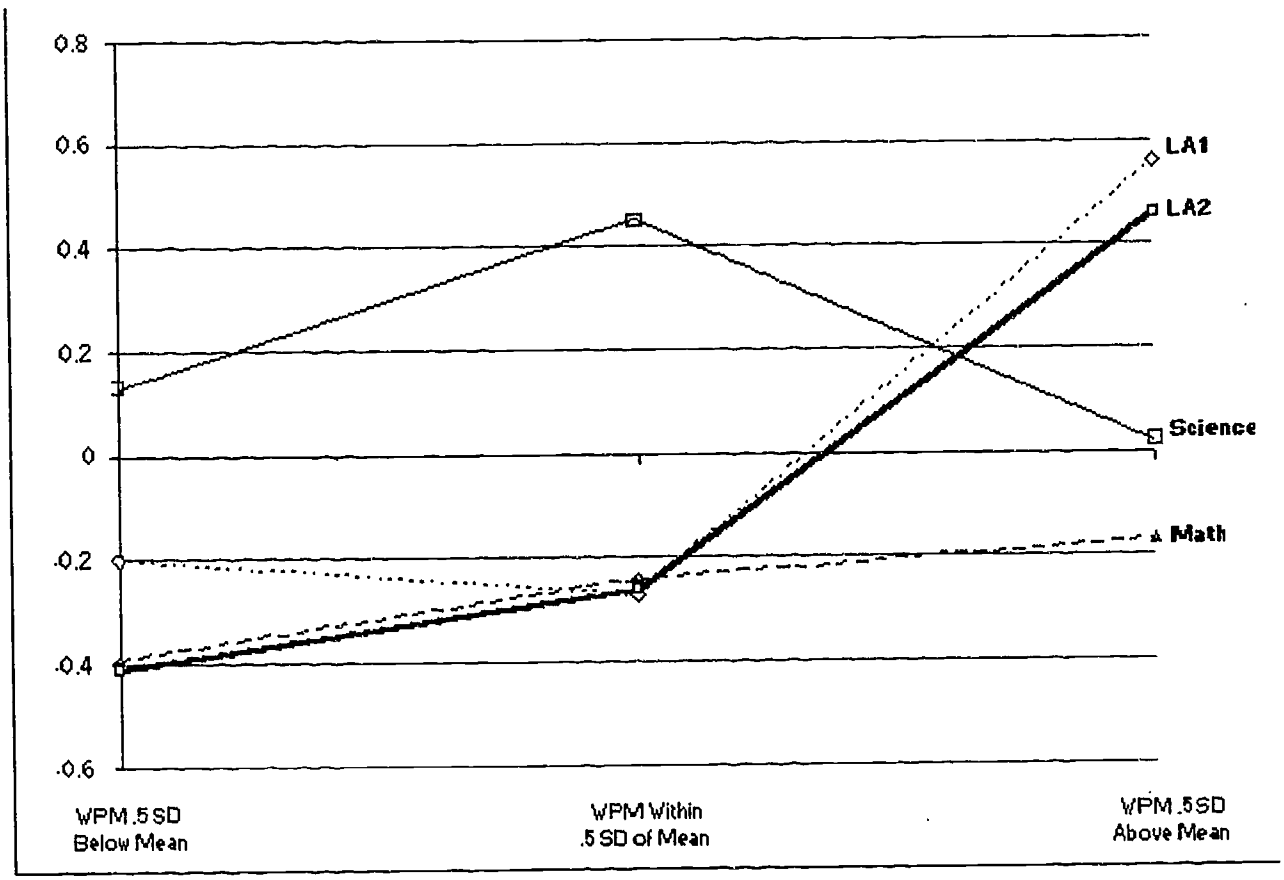


Figure 5: Effect of Comp-Writing on Student Performance Controlling for WPM



Preference and Performance

One of the questions this experiment was designed to address was whether students who performed the test via their preferred medium performed better than predicted and whether those who did not perform the test on their preferred medium performed worse than predicted. Prior to performing either test, students responded to the following survey question: If forced to choose, would you rather write a paper on computer or on paper? To examine the relationship between preference and performance, a dummy variable was coded 1 if the students' preference was the same as the medium on which they performed the test and 0 if their preference and performance medium did not match. For each test, students' test scores were regressed on their SAT 9 scores and Match. Table 25 shows that for the science test, students who took the test on their preferred medium did perform significantly better after controlling for prior achievement. Matching preference with medium of performance did not have a significant effect for the other three tests.

Table 25
Test Score Regressed on SAT 9 and Match

Language Arts 1 Match=43 NoMatch=74					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	.007	.001	.42	4.83	<.0001
Match (1=yes)	-.367	.510	-.06	.72	.47
Adjusted R^2	.15				
Language Arts 2 Match=53 NoMatch=47					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	.005	.001	.40	4.27	<.0001
Match (1=yes)	-.522	.422	-.11	1.24	.22
Adjusted R^2	.15				
Math Match=63 NoMatch=47					
	B	SE B	Beta	T	Signif.
SAT 9 Math	.016	.002	.72	10.80	<.0001
Match (1=yes)	-.948	.561	-.11	-1.69	.09
Adjusted R^2	.52				
Science Match=51 NoMatch=51					
	B	SE B	Beta	T	Signif.
SAT 9 Science	.014	.002	.58	7.46	<.0001
Match (1=yes)	1.487	.646	.18	2.30	.02

Adjusted R^2	.40				

As discussed above, preference for some students seems to have been influenced by social desirablity. As a result, the relationship between preference and performance on the preferred medium may be poorly estimated. Simply giving students the alternative to perform open-ended test questions via their "preferred" medium may not reduce the effect of medium found in this study. Rather, before students are given the choice, it might be useful to explain the apparent relationship between keyboarding speed and performance.

Gender, Keyboarding and Performance on Computers

Resent research suggests that females do not use computers in school as frequently as males (ETS, 1998). If this research is accurate, it is possible that the keyboarding skill of females is less developed than males. Given the relationship between WPM and performance on computer, performing tests on computer may have an adverse impact on the scores for females.

To examine the relationship between gender and WPM, an independent samples t-test was performed using all 229 students included in the study. To examine whether there were gender differences on computer use and prior achievement, t-tests were also performed for Survey, Comp-Writing and the SAT 9 comprehensive NCE. Table 26 indicates that WPM was the only variable for which there was a gender difference. However, on average, it was males' keyboarding speed that was 3 words per minute slower than females. This represents an effect size of approximately .68. This difference, however, does not seem to be caused by less computer experience or less use of computers in the writing process since there were negligible differences for either Survey or Comp-Writing.

Table 26
Gender Differences for WPM, Survey, Comp-Writing and SAT 9 Comprehensive

Males=97 Females=132	Mean	Std. Dev.	SE	T-value	Signif.
WPM					
Males	14.8	4.4	.45		
Females	17.8	5.6	.49	4.41	<.001
Survey					
Males	24.2	5.5	.56		
Females	24.5	5.8	.51	.37	.72
Comp-Writing					
Males	9.4	3.0	.31		
Females	9.6	2.6	.22	.56	.58
SAT 9 Comp.					
Males	408	160	16.3		

Females	398	143	12.4	.48	.63

As described above, WPM was a significant predictor for students' performance on computer in all subject areas. But given that males were on average slower keyboarders, one might expect their scores in all tests to be lower when performed on computer. Table 27 shows that this was the case for all four tests but that the difference was only significant for the first language arts test.

Table 27
Gender Differences for Test Performance on Computers

	Mean	Std. Dev.	SE	T-value	Signif.
LA 1					
Males (26)	4.96	2.60	.51		
Females (34)	6.50	3.22	.55	1.99	.05
LA 2					
Males (24)	4.33	2.57	.52		
Females (31)	5.48	.273	.49	1.59	.12
Math					
Males (21)	8.24	4.38	.96		
Females (35)	9.86	3.51	.59	1.52	.13
Science					
Males (21)	10.48	4.62	1.01		
Females (30)	10.97	3.83	.70	.41	.68

Table 28 shows that gender differences were not found for any tests when prior achievement and WPM were controlled. In part, this finding suggests that although males included in this study tended to be slower keyboarders, they performed as well as females with similar keyboarding and SAT 9 scores. This finding provides further evidence that keyboarding skills play an important role in how well students, regardless of their sex, perform on computers.

Table 28
Test Score Regressed on SAT 9, WPM and Gender for Computer Groups Only

Language Arts 1 N=60					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	.004	.002	.28	2.28	.03
WPM	.258	.072	.45	3.573	.0007
Sex (1=Male)	-.888	.648	-.15	1.37	.18

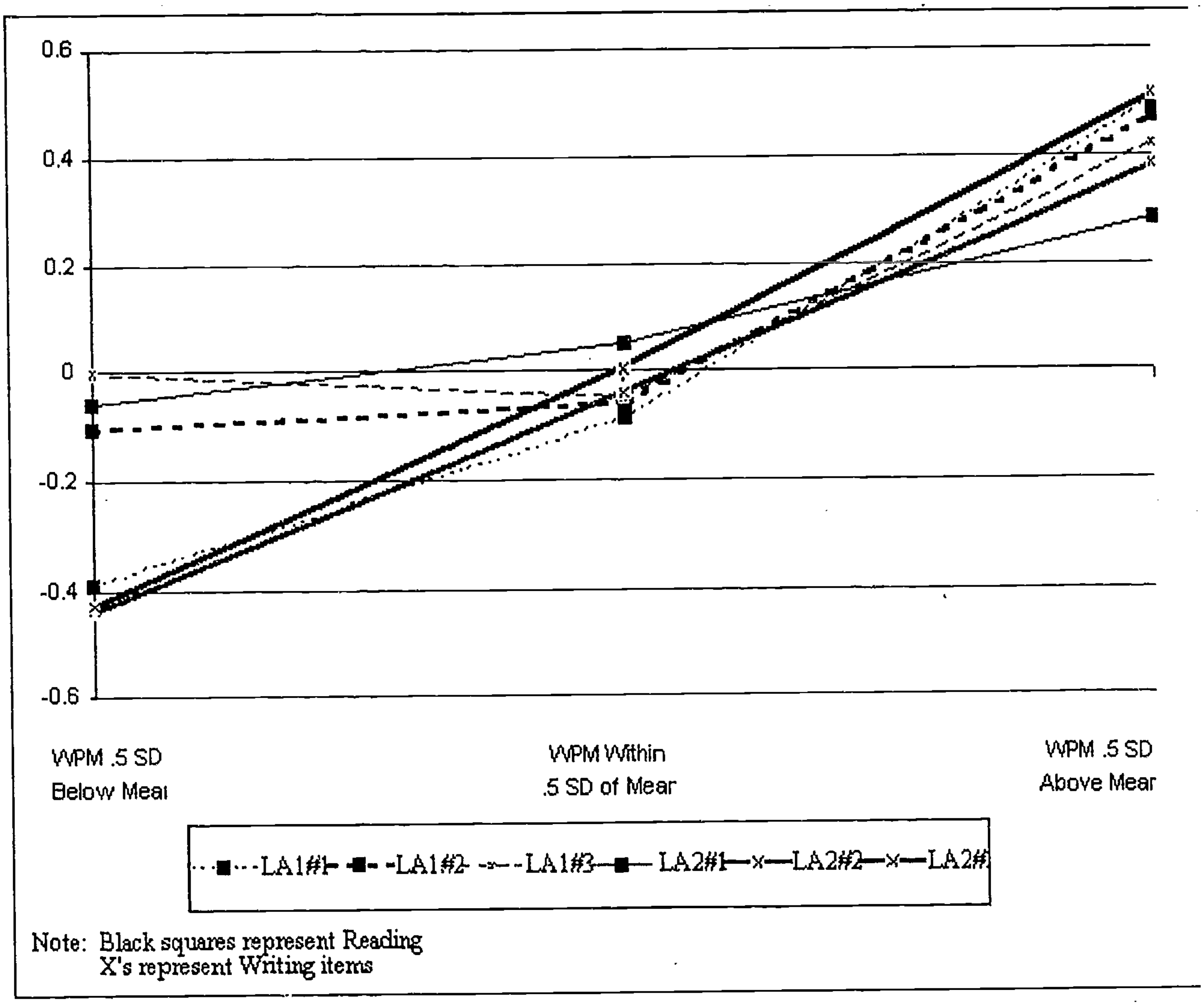
Adjusted R^2	.43				
Language Arts 2 N=55					
	B	SE B	Beta	T	Signif.
SAT 9 Reading	.003	.002	.20	1.51	.14
WPM	.246	.059	.59	4.15	.0001
Sex (1=Male)	.311	.605	.06	.51	.61
Adjusted R^2	.48				
Math N=56					
	B	SE B	Beta	T	Signif.
SAT 9 Math	.011	.002	.53	4.67	.0001
WPM	.177	.089	.23	2.01	.05
Sex (1=Male)	-.605	.833	-.08	.73	.47
Adjusted R^2	.45				
Science N=51					
	B	SE B	Beta	T	Signif.
SAT 9 Science	.011	.003	.49	4.25	.0001
WPM	.266	.095	.33	2.79	.008
Sex (1=Male)	-.379	.935	-.05	.41	.69
Adjusted R^2	.42				

Reading Comprehension vs. Writing Items

For students whose WPM was at least .5 standard deviations below the mean, performing either language arts test on computer had a negative effect on students' test scores. The negative effect was much larger for the second language arts test than it was for the first. To explore why the effect was larger for the second language arts test, the content of the two tests was examined.

Recall that the language arts tests contained two types of items, namely reading comprehension and writing. The first language arts test contained two reading comprehension items and only one writing item while the second language arts test contained two writing items and only one reading comprehension item. To examine the relationship between item type and the effect at each level of keyboarding speed, separate regressions were performed for each item. Figure 6 indicates that the effect for all items are about the same for students whose WPM is within .5 standard deviations of the mean or at least .5 standard deviations above the mean. However, for students whose WPM is at least .5 standard deviations below the mean, there seem to be two different effects. Language arts 1 item 1 and language arts 2 items 2 and 3 all seem to have an effect of about -.4. Language arts 1 item 2 and 3 and language arts 2 item 1 have effects between 0 and -.1. This pattern, however, does not seem to be related to item format. Although language arts 1 item 1 addresses reading comprehension, the two other items showing a similar effect test writing skills. Similarly, although language arts 1 item 2 and language arts 2 item 2 are both reading comprehension, the third item in this triad is a writing item. Thus, item format does not seem to explain the differences in the effect sizes for the two language arts tests at the low level of keyboarding speed.

Figure 6: Effects by Language Arts Item



Explaining Smaller Effect Sizes

As noted above, the magnitude of the effects in this study are about half the size reported by Russell and Haney (1997). While these positive effects are still quite large and represent approximately one half of a standard deviation difference in test scores, there are three observations that may shed some light on why the effects in this study were less pronounced than in the 1997 study.

First, the test scores used in Russell and Haney's study were part of a formal testing program. In the study reported here, the tests were described to students as practice for the spring MCAS administration and thus may not have been taken as seriously by students, especially those unaccustomed to working on computer. This was particularly evident during the computer administration. Whereas the author noted only one student being disciplined during four paper administration sessions that he observed, nearly 40 behavioral problems (e.g., students talking, students touching each other, or students moving around the room without permission) were addressed during the seven computer administration sessions that he observed. This increased level of disruptions may have occurred in part because students were frustrated by their inability to type. These disruptions also may have distracted students who did not experience difficulty keyboarding. Between not being as motivated during a practice test and being distracted more often, students' performance on computer may have suffered. In turn, this may have led to under-estimates of the positive effects and over- estimates of the negative effects.

Second, when the previous study occurred, the ALL school was in its third year of reform and was receiving full external support for its technology reforms. For this reason, there was great enthusiasm for the use of technology by teachers and students. As noted in the previous study, at the time students performed almost all of their work on computer. Since then, three years have passed, there has been a turn-over in teachers, and the external support for the ALL school has largely disappeared. For these reasons, it is possible that students in the ALL School are not using technology as extensively as they did three years ago. This is supported to some extent by the relatively low mean keyboarding speed for students in the ALL school. Although the ALL School's mean WPM was significantly higher than that of the Sullivan Middle School, it was still less than 20 WPM. This low keyboarding speed suggests that although students in the ALL School use computers more often than students in the Sullivan Middle School, their keyboarding skills are not as developed as one might expect if students are using computers on a daily basis. Although there is no direct data to confirm possible decrease use of computers in the ALL School, a decreased use might partially account for the smaller effect.

Finally, given the findings of the previous study and the heavy emphasis the Massachusetts Department of Education has placed on schools' performance on MCAS, it is possible that teachers require students to write more on paper in the ALL School now than three years ago in order to improve their performance on open-ended items. Sadly, after sharing this hypothesis with the ALL School's principal, Carol Shilinsky confirmed that in preparation for MCAS, teachers now require students to perform most of their writing on paper. If this was a successful strategy, then it would have improved students' scores on paper. In turn, the size of the effect of performing the tests on computer would be decreased.

Limitations

Despite efforts to create equivalent groups and to control for the confounding effects of scoring handwritten and computer printed responses, reading extensive passages of text on screen, and only using items that had been formally validated, this study still had several limitations. First, only a small group of students from one urban district were included. Recent research suggests that computers are not used the same way in all schools and that there are meaningful differences in the way students in urban and suburban schools use computers, particularly for math (ETS, 1998). These differences may lead to different effects for students in different settings.

Second, the tests were not administered under formal, controlled testing conditions. This may have decreased motivation, increased distractions and led to under-performance for many students. As noted above, this may be particularly true for students with better keyboarding skills who performed the tests on computer.

Third, although this study included many more open-ended items than did the previous study, testing time for each test was limited to sixty minutes. In order to increase the number of items included in the study, the time required to respond to items was limited, on average, to 10 minutes for math and science and 20 minutes for language arts. This time limit precluded extended writing and extended math items (requiring more than 10 minutes) from the study. However, MCAS and other testing programs include more extended open-ended items. And the effect of performing these types of items on computer may be larger given that in order to perform well, students generally need to produce more text.

Fourth, the sample of students included in this study had relatively slow keyboarding skills. For this reason, it was not possible to estimate the effect of taking open-ended tests on computer for students who are proficient or advanced keyboarders. Given the sharp increase in the size of the effect as keyboarding speed increases from near the mean to .5 standard deviations above the mean, it is possible that the effect of performing tests on computer is even larger for students with more advanced keyboarding skills.

Implications

This study suggests that for students who keyboard about 20 words per minute or more, performing open-ended language arts tests on paper substantially underestimates their level of achievement. However, for slower keyboarders, performing open-ended tests on computer adversely affects their performance. To provide more accurate estimates of students' achievement, these findings suggest that students who can keyboard at a moderate level should be allowed to compose their responses to open-ended items on computers. Conversely, students with weak keyboarding speed should compose their responses on paper.

This study also demonstrates that for math tests, performance on computer underestimates students' achievement regardless of their level of keyboarding speed. This occurred despite efforts to include items that did not require students to draw pictures or graphs to receive credit. Nonetheless, about 20% of the students who performed the math test on computer indicated that they had difficulty showing their work and/or needed scrap paper to work out their solutions. For these reasons, it is likely that the negative effect found in this study underestimates the effect that would occur if a full range of open- ended math items were included.

This study also re-emphasizes the danger of making inferences about students or schools based solely on paper-and-pencil tests. Similarly, as the public investigates the impact computers have on student learning (Oppenheimer, 1997), caution should be taken when student learning is measured by tests containing open-ended items. As found in the previous study, scores on paper and pencil tests for students accustomed to working on computer may substantially under- estimate students' achievement. As computer use in schools and at home continues to increase rapidly, it is likely that more students will develop solid keyboarding skills and, thus, will be adversely affected by taking open-ended tests on paper.

Finally, this study provides further evidence that the validity of open-ended tests should be considered in terms of both content and medium of learning. Until all students have access to and use computers regularly, open-ended tests administered via a single medium, either paper or computer, will likely under- estimate performance of students accustomed to working in the alternate medium. Based on this study, further research on a larger scale into computers and open- ended tests is clearly warranted. Until then, we should exercise caution when drawing inferences about students based on open-ended test scores when the medium of assessment does not match their medium of learning.

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Testing Writing on Computers: An Experiment Comparing Student Performance on Tests Conducted via Computer and via Paper-and-Pencil

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Abstract

Computer use has grown rapidly during the past decade. Within the educational community, interest in authentic assessment has also increased. To enhance the authenticity of tests of writing, as well as of other knowledge and skills, some assessments require students to respond in written form via paper-and-pencil. However, as increasing numbers of students grow accustomed to writing on computers, these assessments may yield underestimates of students' writing abilities. This article presents the findings of a small study examining the effect that mode of administration -- computer versus paper-and-pencil -- has on middle school students' performance on multiple-choice and written test questions. Findings show that, though multiple-choice test results do not differ much by mode of administration, for students accustomed to writing on computer, responses written on computer are substantially higher than those written by hand (effect size of 0.9 and relative success rates of 67% versus 30%). Implications are discussed in terms of both future research and test validity.

Introduction

Two of the most prominent movements in education over the last decade or so are the introduction of computers into schools and the increasing use of "authentic assessments." A key assumption of the authentic assessment movement is that instead of simply relying on multiple choice tests, assessments should be based on the responses students generate for open-ended "real world" tasks. "Efforts at both the national and state levels are now directed at greater use of performance assessment, constructed response questions and portfolios based on actual student work" (Barton & Coley, 1994, p. 3). At the state level, the most commonly employed kind of non-multiple-choice test has been the writing test (Barton & Coley, 1994, p. 31) in which students write their answers long-hand. At the same time, many test developers have explored the use of computer administered tests, but this form of testing has been limited almost exclusively to multiple-choice tests. Relatively little attention has been paid to the use of computers to administer tests which require students to generate responses to open-ended items.

The consequences of the incongruities in these developments may be substantial. As the use of computers in schools and homes increases and students do more of their writing with word processors, at least two problems arise. First, performance tests which require students to produce responses long-hand via paper-and-pencil (which happens not just with large scale tests of writing, but also for assessments of other skills as evidenced through writing) may violate one of the key assumptions of the authentic assessment movement. For people who do most of their writing via computer, writing long-hand via paper-and-pencil is an artificial rather then real world task. Second, and more importantly, paper-and-pencil tests which require answers to be written long-hand to assess students' abilities (in writing or in other subjects) may yield underestimates of the actual abilities of students who are accustomed to writing via computer.

In this article, we present the results of a small study on the effect of computer administration on student performance on writing or essay tests. Specifically, we discuss the background, design and results of the study reported here. However, before focusing on the study itself, we present a brief summary of recent developments in computerized testing and authentic assessment.

In 1968, Bert Green, Jr., predicted "the inevitable computer conquest of testing" (Green, 1970, p. 194). Since then, other observers have envisioned a future in which "calibrated measures embedded in a curriculum . . . continuously and unobtrusively estimate dynamic changes in student proficiency" (Bunderson, Inouye & Olsen, 1989, p. 387). Such visions of computerized testing, however, are far from present reality. Instead, most recent research on computerized testing has focused on computerized adaptive testing, typically employing multiple-choice tests. Perhaps the most widely publicized application of this form of testing occurred in 1993 when the Graduate Record Examination (GRE) was administered nationally in both paper/pencil and computerized adaptive forms.

Naturally, the introduction of computer administered tests has raised concern about the equivalence of scores yielded via computer- versus paper-and-pencil-administered test versions. Although exceptions have been found, Bunderson, Inouye & Olsen (1989) summarize the general pattern of findings from several studies which examined the equivalence of scores acquired through computer or paper- and-pencil test forms as follows: "In general it was found more frequently that the mean scores were not equivalent than that they were equivalent; that is the scores on tests administered on paper were more often higher than on computer-administered tests." However, the authors also state that "[t]he score differences were generally quite small and of little practical significance" (p. 378). More recently, Mead & Drasgow (1993) reported on a meta-analysis of 29 previous studies of the equivalence of computerized and paper-and-pencil cognitive ability tests (involving 159 correlations between computerized and paper-and-pencil test results). Though they found that computerized tests were slightly harder than paper-and-pencil tests (with an overall cross-mode effect size of -.04), they concluded that their results "provide strong support for the conclusion that there is no medium effect for carefully constructed power tests. Moreover, no effect was found for adaptivity. On the other hand, a substantial medium effect was found for speeded tests" (Mead & Drasgow, 1993, p. 457).

Yet, as previously noted, standardized multiple-choice tests, which have been the object of comparison in previous research on computerized versus paper-and-pencil testing, have been criticized by proponents of authentic assessment. Among the characteristics which lend authenticity to an assessment instrument, Darling-Hammond, Ancess & Falk (1995) argue that the tasks be "connected to students' lives and to their learning experiences..." and that they provide insight into "students' abilities to perform 'real world' tasks" (p.4-5). Unlike standardized tests, which may be viewed as external instruments that measure a fraction of what students have learned, authentic assessments are intended to be closely linked with daily classroom activity so that they seamlessly "support and transform the process of teaching and learning" (Darling-Hammond, Ancess & Falk, 1995, p. 4; Cohen, 1990).

In response to this move towards authentic assessment, many developers of nationally administered standardized tests have attempted to embellish their instruments by including open-ended items for which students have to write their answers. These changes, however, have occurred during a period when both the real-world and the school-world have experienced a rapid increase in the use of computers.

The National Center for Education Statistics report that the percentage of students in grades 1 to 8 using computers in school has increased from 31.5 in 1984, to 52.3 in 1989 and to 68.9 in 1993 (Snyder & Hoffman, 1990; 1994). In the workplace, the percentage of employees using computers has risen from 36.0 in 1989 to 45.8 in 1993. During this period, writing has been the predominant task adult workers perform on a computer (Snyder & Hoffman, 1993; 1995). Given these trends, tests which require students to answer open-ended items via paper-and-pencil may decrease the test's "authenticity" in two ways: 1. Assessments are not aligned with students' learning experiences; and 2. Assessments are not representative of 'real-world' tasks. As the remainder of this paper suggests, these shortcomings may be leading to underestimates of students' writing abilities.

Background to this Study

In 1993, the Advanced Learning Laboratory School (ALL School, (http://nis.accel.worc.k12.ma.us) of Worcester, Massachusetts decided to adopt the Co-NECT school design (or Cooperative Networked Educational Community for Tomorrow, http://co-nect.bbn.com). Developed by BBN, Inc., a Boston- based communications technology firm, Co-NECT is one of nine models for innovative schooling funded by the New American Schools Development Corporation. Working with BBN, the ALL School restructured many aspects of its educational environment. Among other reforms, the traditional middle school grade structure (that is, separately organized grade 6, 7 and 8 classes) was replaced with blocks which combined into a single cluster students who otherwise would be divided into grades 6, 7 and 8. In place of traditional subject-based classes (such as English Class, Math Class, Social Studies, etc.), all subjects were integrated and taught through project-based activities. To support this cooperative learning structure, several networked computers were placed in each classroom, allowing students to perform research via the Internet and CD-ROM titles, to write reports, papers and journals, and to create computer based presentations using several software applications.

To help evaluate the effects the restructuring at the ALL School has on its students as a whole, the Center for the Study of Testing, Evaluation and Educational Policy (CSTEEP) at Boston College helped teachers gather baseline data in the fall of 1993 with plans to perform follow-up assessments in the spring of 1994 and each spring thereafter. To acquire a broad picture of students' strengths and weaknesses, the forms of tests included in the baseline assessment ranged from multiple choice tests to short and long answer open-ended assessments to hands-on performance assessments covering a wide range of reading, writing, science and math skills. To acquire insight into how cooperative projects affected the development of group skills, some of the performance assessments required students to work together to solve a problem and/or answer specific questions. Finally, to evaluate how the Co-NECT Model, as implemented in the ALL School, affected students' feelings about their school, a student survey was administered. Assessments and surveys were administered to representative samples of the whole school's student population.

In the spring of 1994, the same set of assessments was re-administered to different representative samples of students. While a full discussion of the results is beyond the scope of this paper, many of the resulting patterns of change were as expected. For example, performance items which required students to work cooperatively generally showed more improvement than items which required students to work independently. On items that required students to work independently, improvement was generally stronger on open-ended items than on multiple-choice items. But there was one notable exception: open-ended assessments of writing skills suggested that writing skills had declined.

Although teachers believed that the Co-NECT Model enhanced opportunities for students to practice writing, performance on both short answer and long answer writing items showed substantial decreases. For example, on a short answer item which asked students to write a recipe for peace, the percentage of students who responded satisfactorily decreased from 69% to 51%. On a long answer item which asked students to imagine a superhero, describe his/her powers, and write a passage in which the superhero uses his/her powers, the percentage of satisfactory responses dropped from 71% to 41%. On another long answer item that asked students to write a story about a special activity done with their friends or family, student performance dropped from 56% to 43%. And on a performance writing item which first asked students to discuss what they saw in a mural with their peers and then asked them to write a passage independently that described an element in the mural and explain why they selected it, the percentage of satisfactory responses decreased from 62% to 47%. These declines were all statistically significant, and more importantly were substantively troubling.

Since writing was a skill the school had selected as a focus area for the 1993-94 school year, teachers were surprised and troubled by the apparent decrease in writing performance. During a feedback session on results in June 1994, teachers and administrators discussed at length the various writing activities they had undertaken over the past year. Based on these conversations, it was evident that students were regularly presented with opportunities to practice their writing skills. But a consistent comment was that teachers in the ALL School were increasingly encouraging students to use computers and word processing tools in their writing. As several computers were present in all classrooms, as well as in the library, teachers believed that students had become accustomed to writing on the computer. When one teacher suggested that the decrease in writing scores might be due to the fact that all writing items in spring 1994 were administered on paper and required students to write their responses by hand, the theory was quickly supported by many teachers. With a follow-up assessment scheduled to occur a year later, several teachers asked if it would was possible for students to perform the writing items on a computer.

After careful consideration, it was decided that a sub- sample of students in spring 1995 would perform a computer- administered version of the performance writing item and items from the National Assessment of Educational Progress (NAEP) (items were mostly multiple-choice with a few short answer items included). But, to preserve comparisons with results from 1993-94, the majority of the student population would perform these assessments as they had in that year -- via the traditional pencil-and-paper medium. Hence, we undertook an experiment to compare the effect that the medium of administration (computer versus paper-and-pencil) has on student performance on multiple-choice, short-answer and extended writing test items.

Study Design and Test Instruments

To study the effect the medium of administration has on student performance, that is taking assessments on computer versus by hand on paper, two groups of students were randomly selected from the ALL School Advanced Cluster (grades 6, 7 and 8). For the experimental group, which performed two of three kinds of assessments on computer, 50 students were selected. The control group, which performed all tests via pencil-and-paper, was composed of the 70 students required for the time-trend study described above. The three kinds of assessments performed by both groups were:

1. An open-ended (OE) assessment comprising 14 items, which included two writing items, five science items, five math items and two reading items.
2. A test comprised of NAEP items which was divided into three sections and included 15 language arts items, 23 science items and 18 math items. The majority of NAEP items were multiple-choice. However, 2 language arts items, 3 science items and 1 math item were open-ended and required students to write a brief response to each item's prompt.
3. A performance writing assessment which required an extended written response.

Both groups performed the open-ended (OE) assessment in exactly the same manner, by hand via paper-and pencil. The experimental group performed the NAEP and writing assessment on computer, whereas the control group performed both in the traditional manner, by hand on paper.

The performance writing assessment consisted of a picture of a mural and two questions. Students formed small groups of 2 or 3 to discuss the mural. After 5 to 10 minutes, students returned to their seats and responded to one of two prompts:

1. Now, it is your turn to pick one thing you found in the mural. Pick one thing that is familiar to you, that you can recognize from your daily life or that is part of your culture. Describe it in detail and explain why you chose it.
2. Artists usually try to tell us something through their paintings and drawings. They may want to tell us about their lives, their culture or their feelings about what is happening in the neighborhood, community or world. What do you think the artists who made this mural want to tell us? What is this mural's message?

Due to absences, the actual number of students who participated in this study was as follows:

Experimental (Computer) Group: 46
Control (Paper-and-Pencil) Group: 68

It should be noted that the study described in this paper was performed as part of a larger longitudinal study which relied heavily on matrix sampling. For this reason, not all of the students in the control group performed all three tests. However, all students included in the analyses reported here performed at least two tests, one of which was the open-ended assessment. Table 1 shows the actual number of students in each group that performed each test.

Table 1
Number of Students Performing Each Test

Test	Experimental	Control	Total
Open-ended	46	68	114
NAEP	44	42	86
Perf. Writing	40	46	86

To be clear, we emphasize that the treatment, in terms of which the experimental and control groups differed, had nothing to do with educational experience of the two groups. The groups were receiving similar -- albeit quite unusual in comparison to most middle schools -- educational experiences in the ALL school. The treatment, in terms of which the two groups differed, was simply that the experimental group took the NAEP and performance writing tests on computer, whereas the control group took these tests in the traditional manner, by hand with paper-and-pencil.

Converting Paper Tests to Computer

Before the tests could be administered on computer, the paper versions were converted to a computerized format. Several studies suggest that slight changes in the appearance of an item can affect performance on that item. Something as simple as changing the font in which a question is written, the order items are presented, or the order of response options can affect performance on that item (Beaton & Zwick, 1990; Cizek, 1991). Other studies have shown that people become more fatigued when reading text on a computer screen than when they read the same text on paper (Mourant, Lakshmanan & Chantadisai, 1981). One study (Haas & Hayes, 1986) found that when dealing with passages that covered more than one page, computer administration yielded lower scores than paper-and-pencil administration, apparently due to the difficulty of reading extended text on screen. Clearly, by converting items from paper to computer, the appearance of items is altered.

To minimize such effects, each page of the paper version of the NAEP items and the performance writing item was replicated on the computer screen as precisely as possible. To that end, the layout of text and graphics on the computer version matched the paper version, including the number of items on a page, the arrangement of response options, and the positioning of footers, headers and directions. Despite these efforts, not every screen matched every page. Since the computer screen contained less vertical space, it was not always possible to fit the same number of questions on the screen as appeared on the page. In addition, to allow the test taker to move between screens (e.g., to go on to the next screen, back to a previous screen, or to flip to a passage or image to which an item referred), each screen of the computer versions contained navigation buttons along its bottom edge. Finally, to decrease the impact of screen fatigue, a larger font was used on the computer version than on the paper version.

To create a computerized version of the NAEP and performance writing tests, the following steps were taken:

1. An appropriate authoring tool was selected. To fully integrate the several graphics used in the multiple-choice items and the full-color photograph of a mural used in the performance writing item, as well as to track students' responses, Macromedia Director was used.
2. All graphics and the photograph of the mural were scanned. Adobe Photoshop was used to retouch the images.
3. A data file was created to store student input, including name, ID number, school name, birth date, gender, date of administration and responses to each item.
4. A prototype of each test was created, integrating the graphics, text and database into a seamless application. As described earlier, navigational buttons were placed along the lower edge of the screen. In addition, a "cover" page was created in which students entered biographical information.
5. The prototype was tested on several adults and students to assure that all navigational buttons functioned properly, that data was stored accurately, and that items and graphics were easy to read.
6. Finally, the prototype was revised as needed and the final versions of the computer tests were installed on twenty-four computers in the ALL School.

As described above, the addition of navigational buttons along the lower edge of the computer screen was the most noticeable difference between the computer and paper versions of the tests. To allow students to review their work and make changes as desired, a "Next Page" and "Previous Page" button appeared on all pages (or screens) of the computer tests (except the first and last page). To allow students to review their work, student responses were not recorded until the student reached the last page of the assessment and clicked a button labeled "I'm Finished." When the "I'm Finished" button was clicked, the student's biographical information and responses to each item were recorded in a data file before the program terminated. For all multiple-choice items, students clicked the option they felt best answered the question posed. For both short- and long-answer questions, examinees used a keyboard to type their answers into text boxes which appeared on their screen. Though they could edit using the keyboard and mouse, examinees did not have access to word processing tools such as spell-checking.

Scoring

A combination of multiple choice and open-ended items were performed by both groups of students. Multiple-choice NAEP items were scored as either correct or incorrect based upon the answer key accompanying the NAEP items. To prevent rater bias based on the mode of response, all short-answer NAEP responses were entered verbatim into the computer. Responses of students who had taken the NAEP questions on computer and via paper-and-pencil were then randomly intermixed. Applying the rating rubrics designed by NAEP, two raters independently scored each set of six short answer items for each student. As part of an overall strategy to summarize results on all items in terms of percent correct, the initial ratings (which ranged from 1 - 5) were converted to a dichotomous value: 1 or 0; to denote whether student responses were adequate or inadequate. The two raters' converted scores were then compared. Where discrepancies occurred, the raters re-evaluated responses and reached consensus on a score.

To score the performance writing item, all hand written responses were entered verbatim into the computer -- again so as to prevent raters from knowing which responses were originally written by hand. The hand-written and computer- written responses were randomly intermixed.

Three independent raters then scored each written response, using the following four-point scoring rubric:

1. Too brief to evaluate: Student did not make an attempt; indicates that student either did not know how to begin, or could not approach the problem in an appropriate manner.
2. Inadequate Response: Student made an attempt but the response was incorrect, reflected a misconception and/or was poorly communicated.
3. Adequate Response: Response is correct and communicated satisfactorily, but lacks clarity, elaboration and supporting evidence.
4. Excellent Response: Response is correct, communicated clearly and contains evidence which supports his/her response.

Initial analyses of the three raters' ratings showed that there was only a modest level of inter-rater reliability among the three (inter-rater correlations ranged from 0.44 to 0.62, across the total of 89 performance writing responses). Although these correlations were lower than expected, research on the assessment of writing has shown that rating of writing samples, even among trained raters, tends to be only modestly reliable (Dunbar, Koretz, & Hoover, 1991). Indeed, that is why we planned to have more than one rater evaluate each student response to the performance writing task. Hence for the purpose of the study reported here we created composite performance rating scores by averaging the three ratings of each student's response (which we call PWAvg).

Since the open-ended assessment was performed by paper- and-pencil by all students, student responses were not entered into the computer. A single rater, who did not know which students had performed other assessments on the computer, scored all responses using a 4 point scale. Although each of the 14 items had its own specific scoring criteria, the general meaning of each score was the same across all 14 open-ended items, as well as the performance writing item. The raw scores were then collapsed into a 0, 1 scale, with original scores of 1 or 2 representing a 0, or inadequate response, and original scores of 3 or 4 representing a 1, or adequate response. For the purpose of the study reported here, total open-ended response scores were calculated by summing across all 14 OE items.

Results

In presenting results from this study, we discuss: 1) assessment results overall; 2) comparative results from the two groups that took assessments via computer or via paper-and-pencil; 3) results of regression analyses; and 4) separate analyses of performance on the short-answer and multiple-choice NAEP items.

We present descriptive data summaries before results of statistical tests. Regarding the latter, we note that this experiment involved multiple comparisons of results based on just two random samples of students. While the literature on how to adjust alpha levels to account for multiple comparisons (e.g. Hancock & Klockars, 1996) is too extensive to review here, let us simply summarize how we dealt with this issue. We planned to compare results for the experimental and control groups on five different measures: OE, performance writing, and three NAEP subtests, in science, math, and language arts. The Dunn approach to multiple comparisons tells us that the α for *c* multiple comparisons, α_{pc}, is related to simple α for a single comparison, as follows:

$$\alpha_{pc} = 1 - (1-\alpha)^{1/c}$$

Hence for five comparisons, the adjusted value of a simple 0.05 alpha level becomes 0.0102.

Analogously, a simple alpha level of 0.01 for a single comparison becomes 0.0020 for five planned comparisons. We use these alpha levels in discussing the statistical significance of comparisons between experimental and control group results. In discussion, we address not just the statistical significance, but also the substantive significance of our findings.

Overall Results

The actual raw data on which all analyses are based is being made available to the reader. From this point, the data files can be accessed in ASCII or EXCEL Spreadsheet (binary) form.

Table 2 presents a summary of overall results, that is, combined results for all students who took any of the three assessments in Spring 1995.

Table 2
Summary Statistics for All Assessments

	Scale Range	n	Mean	SD
OE	0-14	114	7.87	2.96
NAEP Lang Arts	0-15	86	9.84	3.79
NAEP Science	0-23	86	9.70	4.37
NAEP Math	0-18	86	6.21	3.39
Perf Writing Avg	1-4	86	2.53	0.62

These data indicate that the assessments were relatively challenging for the students who performed them. Mean scores were in the range of 56-66% correct for the OE and NAEP Language Arts tests, but considerably below 50% correct for the NAEP science and NAEP math subtests. In this regard, it should be noted that all of these assessments were originally designed to be administered to eighth graders, but in the study reported here they were administered to 6th, 7th and 8th grade level students who in the ALL school are intermixed in the same clusters.

Table 3 presents Spearman rank order intercorrelations of all assessments, again across both groups. The OE results correlated only slightly higher with the PWAvg results, possibly reflecting the fact that both of these assessments were open-ended requiring students to produce rather than select an answer. The three NAEP item subtests showed moderate intercorrelations (0.56-0.62) which might be expected for multiple-choice tests in the different subject areas (despite the fact that none of the NAEP subtests contained as many as two dozen items). The PWAvg results showed modest correlations with the NAEP subtests. Of the three NAEP sub-tests, the PWAvg was most strongly correlated with the Science sub-test. Although the NAEP science results were based largely on multiple choice items, of the three NAEP subtests, the Science section contained the largest number of short answer items (3 out of 23 items). The NAEP subtest that correlated least with the PWAvg scores (0.37) was the NAEP Math subtest, which contained only one open-ended item.

Table 3
Intercorrelations of Assessment Results

	OE	NAEP Lang Arts	NAEP Science	NAEP Math	Perf. Writing

OE	1.00				
NAEP Lang Arts	0.46	1.00			
NAEP Science	0.44	0.62	1.00		
NAEP Math	0.40	0.56	0.57	1.00	
Perf Writing	0.48	0.49	0.54	0.37	1.00

p <.01 for all intercorrelations

Computer versus Paper-and-Pencil Results

Table 4 presents results separately for the experimental and control groups, namely the group which took NAEP and performance writing assessments on paper and the one that took them on computer. The table also shows results of t-tests (for independent samples, assuming equal variances for the two samples and hence using a pooled variance estimate). As an aid to interpretation, the table also shows the effect of computer administration in terms of Glass's delta effect size, that is the mean of the experimental group minus the mean of the control group divided by the standard deviation of the control group. While other methods for calculating effect size have been proposed (Rosenthal, 1994, p. 237), note that results would not differ dramatically if a pooled standard deviation were used instead of the control group standard deviation.

Results indicate that, after adjusting for the planned multiple comparisons, the effect of computer administration was significant only for the PWAvg. The effect size of computer administration on the performance writing task was 0.94.

The four tests which did not show a statistically significant difference between the two groups were the OE test and the NAEP Language Arts, Science, and Math tests. The absence of a statistically significant difference on the OE test was, of course, expected since the OE test was the one test that was administered in the same form (paper-and- pencil) to the two groups. Similarly, since the NAEP tests were primarily composed of multiple-choice items, which previous research suggests are affected minimally by the mode of administration, differences between the two groups on the NAEP tests were not expected. Note however that the size of the difference in OE scores between the two groups was surprisingly large, given that the two groups had been randomly selected. The absence of four students randomly selected for the experimental group who did not take any tests may partially explain this difference. Nevertheless to explore the possibility that group differences may partially account for apparent mode of administration effects (and also, of course, to estimate effects more precisely), regression analyses were conducted.

Table 4
Summary Results by Group

	Control			*Experimental*					
	n	Mean	SD	n	Mean	SD	Effect Size (df)	t	Sig
OE	68	7.62	3.14	46	8.24	2.66	0.20 (112)	1.10	0.27
Lang Arts	42	9.24	3.96	44	3.58	0.30	0.30 (84)	1.44	0.15
Science	42	8.67	4.17	44	10.68	4.39	0.48 (84)	2.18	0.03
Math	42	6.00	3.30	44	6.41	3.51	0.12 (84)	0.56	0.58
Perf Writ.	46	2.30	0.55	40	2.81	0.59	0.94 (84)	4.16	<.0001**

** statistically significant at the 0.01 level after taking multiple comparisons into account

Regression Analyses

As a further step in examining the effects of mode of administration, regression analyses were conducted using the OE scores as a covariate and then introducing a dummy variable (0= paper/pencil group; 1= computer administration group) to estimate the effects of mode of administration on the NAEP Language Arts, Science and Math subtests and on the PWAvg scores. Results of these regression analyses are shown in Table 5.

Table 5
Results of Regression Analyses

Dependent Variable	Coeff	SE	t-ratio	Sig
NAEP Lang Arts				
Constant	5.03	1.09	4.60	<.0001**
OE	0.57	0.13	4.40	<.0001**
Group*	0.66	0.75	0.89	0.38
NAEP Science				
Constant	3.72	1.23	3.02	.0033
OE	0.67	0.15	4.59	<.0001**
Group*	1.42	0.84	1.69	0.09
NAEP Math				
Constant	1.99	0.97	2.04	<.0445
OE	0.54	0.12	4.70	<.0001**
Group*	-0.07	0.67	0.11	0.91
Perf Writing				
Constant	1.59	0.16	9.73	<.0001**
OE	0.09	0.02	4.88	<.0001**
Group*	0.44	0.11	3.98	.0001**

* (1=computer)

** statistically significant at the 0.01 level after taking multiple comparisons into account

These results confirm the findings shown in Table 4, namely that even after controlling for OE scores, the effect of mode of administration was highly significant on the PWAvg. However, for the largely multiple-choice NAEP subtests, results indicate no difference for mode of administration.

Performance on Multiple Choice and Short-Answer NAEP Items

Although the regression analysis suggested that mode of administration did not significantly influence performance on the NAEP subtests, further analysis was performed on the NAEP subtest items to examine the effect of administration mode on the two forms of items contained in the NAEP subtest -- multiple-choice and short answer. Table 6 shows the mean score for the two groups on both the multiple-choice items and the short-answer items for the three subtests.

Although slight differences between the means were found for the multiple-choice items, none were significant. However, for the science and language arts short answer items, those students who responded on computer performed significantly better than the paper-and-pencil group. While it was expected that performance on multiple-choice items would not differ, the differences detected on the short answer items suggest that even for items that require a brief written response, the mode of administration may affect a student's performance.

The question arises as to why the mode of administration affected performance on the short answer Language Arts and Science questions, but not on the one short-answer Math item. It is likely that the nature of the open-ended Math item accounts for similar performance between the two groups. The open-ended Math question required a short answer which could not be provided without correctly answering the multiple-choice question that preceeded it. In contrast, the three short answer Science items asked students to interpret data in a table, explain their process and respond to a factual item. In particular, the second short answer Science item provided a fair amount of space for a response and many students wrote at least one complete sentence. Although the three Science items were related to the same set of data displayed in a table, response to these items were not dependent on answers to previous items.

Table 6: Results of Analysis of NAEP Subtest Item formats: Multiple-choice versus Short Answer

Items	n	Control Mean	SD	n	Experimental Mean	SD	Effect Size	t	Sig
Lang. Arts									
Mult. Choice	42	8.6	3.47	44	9.0	3.03	0.12	0.64	.522
Short Answer	42	0.6	0.73	44	1.4	0.75	0.99	4.52	<.0001**
Science									
Mult. Choice	42	8.0	3.97	44	9.0	3.99	0.26	1.22	.226
Short Answer	42	0.7	0.77	44	1.7	0.98	1.25	5.06	<.0001**
Math									
Mult. Choice	42	5.8	3.07	44	6.1	3.33	0.10	0.44	.660
Short Answer	42	0.2	0.41	44	0.3	0.47	0.25	1.08	.282

** statistically significant at the 0.01 level after taking multiple comparisons into account

To inquire further into the apparent effect of mode of administration on short answer Language Arts and Science items, we conducted regression analyses, using OE scores as a covariate. Results, shown in Table 7 indicate that the mode of administration had a significant effect on the students' performances on the NAEP Language Arts and Science short-answer items.

Table 7: Results of Regression Analyses on NAEP Language Arts and Science Short-Answer Items

Dependent Var	Ccef.	s.e.	beta	s.e.	t-ratio	Sig
NAEP Lang Arts						
Constant	-0.08	0.22			-.38	.71
OE	0.10	0.03	0.35	0.09	3.77	.0003**

Group*	0.63	0.15	0.39	0.09	4.23	.0001**
NAEP Science						
Constant	0.20	0.28			0.74	.4645
OE	0.07	0.03	0.20	0.09	2.09	.0397
Group*	0.91	0.19	0.45	0.09	4.77	<.0001**

* (1=computer)

** statistically significant at the 0.01 level after taking multiple comparisons into account

Discussion

The experiment described here was a small inquiry aimed at investigating a particular question. Motivated by a question as to whether or not performance on an extended writing task might be better if students were allowed to write on computer rather than on paper, the study aimed at estimating the effects of mode of administration on test results for two kinds of assessments, namely the largely multiple-choice NAEP subtests and the extended writing task previously described. Unlike most previous research on the effects of computer administered tests, which has focused on multiple-choice tests and has generally found no or small differences due to mode of administration, our results indicate substantial effects due to mode of administration. The size of the effects was found to be 0.94 on the extended writing task and .99 and 1.25 for the NAEP language arts and science short answer items. Effect sizes of this magnitude are unusually large and of sufficient size to be of not just statistical, but also practical significance (Cohen, 1977; Wolf, 1986). An effect size of 0.94, for example, implies that the score for the average student in the experimental group exceeds that of 83 percent of the students in the control group.

A number of authors have noted the difficulty of interpreting the practical significance of effect sizes and have suggested that one useful way of doing so is with a "binomial effect size display" showing proportions of success and failure under experimental and control conditions (Hedges & Olkin, 1985; Rosenthal & Rubin, 1982). While there are a number of ways in which effect sizes, expressed as either Glass's delta or a correlation coefficient, can be converted to a binomial effect size display, in the case of our PWAvg scores, we have a direct way of showing such a display. Recall that student responses to the performance writing item were scored on a 4-point scale in which scores of 1 and 2 represented a less than adequate response and scores of 3 and 4 represented an adequate or better response. Using the cut-point of 2.5 as distinguishing between inadequate (failure) and adequate (success) responses in terms of PWAvg scores, we may display results as shown in Table 8.

Table 8: Binomial Effect Size Display of Experimental Results: In Terms of Inadequate vs. Adequate PWAvg Scores

Control (Paper)	Inadequate	Adequate
N	32	14
Percent	69.6%	30.4%
Experimental (Computer)	Inadequate	Adequate
N	13	27
Percent	32.5%	67.5%

This display indicates that the computer mode of administration had the effect of increasing the success rate on the performance writing item (as judged by the average of three independent raters) from around 30% to close to 70%.

As a means of inquiring further into the source of this large effect, we conducted a variety of analyses to explore why and for whom the mode of administration effect occurred. To explore why the mode of administration effect may have occurred, we first undertook a textual analysis of student responses to the extended writing task. Specifically we calculated the average number of words and paragraphs contained in the responses of both groups. As Table 9 below indicates, those students who performed the assessment on the computer tended to write almost twice as much and were more apt to organize their responses into more paragraphs.

Table 9: Characters, Words and Paragraphs on Performance Writing Task by Mode of Administration

		Characters	Words	Paragraphs
Control (Paper)				
	Mean	586.9	111.6	1.457
	Std	275.58	52.47	1.069
	n	46	46	46
Experimental (Computer)				
	Mean	1022.2	204.7	2.625
	Std	549.55	111.32	2.306
	n	40	40	40
	observed t with pooled variance	4.73	5.07	3.08
	sig	<.0001**	<.0001**	<.0001**

** statistically significant at the 0.01 level after taking multiple comparisons into account

In some ways, this pattern is consistent with the findings of Daiute (1985) and Morocco and Neuman (1986), who have shown that teaching writing with word processors tends to lead students to write more and to revise more than when they write with paper-and-pencil. Not surprisingly, the length of students' written responses (in terms of numbers of characters and words correlated significantly with PWAvg scores, 0.63 in both cases). Although this suggests that longer responses tended to receive higher scores, the fact that length of response explains less than half of the variance in PWAvg scores suggests that rated quality is not attributable simply to length of response.

Second, we considered the possibility that motivation might help explain the mode of administration effect. This possibility was suggested to us by spontaneous comments made by students after the testing. For example, after taking the writing assessment on computer, one student commented, "I thought we were going to be taking a test." In contrast, a student in the control group, who had not taken any tests via computer, inquired of us, "How come we didn't get to take the test on computer?" Such comments raised the possibility that motivation and the simple novelty of taking tests on computer might explain the mode of administration effect we found.

Two lines of thought suggest that simple motivation cannot explain our results. If differential motivation arising from the novelty of taking tests on computer was the main cause of our results, it is hard to explain why mode of administration effects were absent on the multiple-choice NAEP subtests, but were prevalent on the performance writing test and the NAEP open-ended items. Furthermore, recent research on the effects of motivation on test performance, suggests that the effects of motivation are not nearly as large as the mode of administration effect we found on the performance writing test. Recently, Kiplinger & Linn (1996) reported on the effects of an experiment in which "low- stakes" NAEP items were embedded in a "high stakes" state testing program in Georgia. Though results from this experiment were mixed, the largest effects of "high stakes" motivation occurred for nine NAEP items designed for eighth grade students. For these nine items, however, the effect size was only 0.18. (Kiplinger & Linn, 1996, p.124). In a separate study, O'Neill, Sugrue & Baker (1996) investigated the effects of monetary and other incentives on the performance of eighth grade students on NAEP items. Again, though effects of these motivational conditions were mixed, the largest influence of motivation ranged from an effect size of 0.16 to 0.24 (O'Neill, Sugrue & Baker, 1996, p. 147). With the largest effects of motivation on eighth grade students found to be in the range of 0.16 to 0.24, these results suggest that motivation alone cannot explain the magnitude of mode of administration effects we found for written responses.

To examine for whom the mode of administration effects occurred, we also inquired into whether the mode of administration effect appeared to be different for different students. First we inquired into whether the mode of administration effect seemed to be different for students performing at different levels on the OE test. One simple way of testing this possibility was to calculate PWAvg scores predicted on the basis of OE scores and see if there was a statistically significant correlation between residuals (actual minus predicted PWAvg scores) and OE scores among the experimental group students. No significant correlation was found, suggesting that the mode of administration effect was not different for students of different ability levels as indicated by their OE scores. A graphical presentation of this pattern is shown in Figure 1, which depicts the line of PWAvg scores regressed on OE scores, with the experimental cases represented with X's and the control group with dots. As can be seen in Figure 1, the actual PWAvg scores for the experimental group tended to exceed the predicted scores across ability levels as represented by the OE scores.

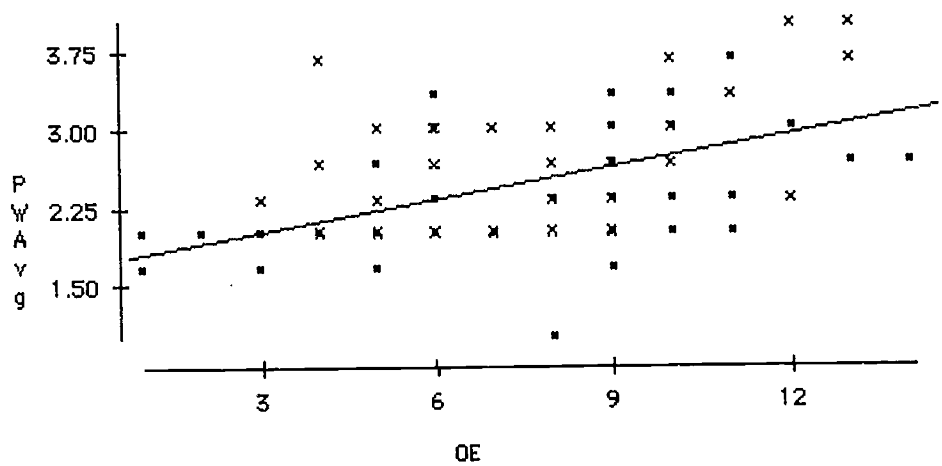

Figure 1: Regression of PWAvg scores on OE Scores

Finally, we explored whether mode of administration effect seemed to differ for males versus females. Table 10 shows PWAvg scores by gender for both control and experimental groups.

Table 10: PWAvg Scores by Gender and Group

		Female	Male	Total
Control (Paper)				
	Mean	2.33	2.27	2.30
	SD	0.58	0.47	0.55
	n	21	25	46
Experimental (Computer)				
	Mean	2.92	2.60	2.81
	SD	0.53	0.63	0.59
	n	26	14	40
Total				
	Mean	2.66	2.38	2.53
	SD	0.65	0.54	0.62
	n	46	39	86

Within the control groups, females performed only slightly better on PWAvg scores than did males (with means 2.33 and 2.27 respectively). However within the experimental group females scored considerably better than males (with means of 2.92 and 2.60). Thus it appears that the effect of computer administration may have been somewhat larger for females than for males. Nonetheless the males who took the extended writing task on computer still performed considerably better than the females who took the writing task on paper (with respective means of 2.60 and 2.33). A two way analysis of variance (PWAvg by gender and group) showed group but not gender to be significant (this was the case whether or not an interaction term was included). This general pattern was confirmed by regression analyses of PWAvg scores on OE scores, sex and group. Though OE scores and the group variable were significant, the sex variable was not.

We should note that post hoc, we were surprised that the proportion of males in the control group (54%) differed by nearly 19 percentage points from the proportion of males in the experimental group (35%). Although the two groups were selected randomly, the probability that this difference would occur is less than .08. However, as can be calculated based on the data in Table 10, even after controlling for gender, the average effect size is 0.86.

Although the experiment reported here had several weaknesses--only one extended writing task was used, no other variables on academic achievement beyond the OE test results were used as covariates in regression analyses, and information on students' extent of experience working on computers was not collected--further research into this topic clearly is warranted.

Increasingly, schools are encouraging students to use computers in their writing. As a result, it is likely that increasing numbers of students are growing accustomed to writing on computers. Nevertheless, large scale assessments of writing, at state, national and even international levels, are attempting to estimate students' writing skills by having them use paper-and-pencil. Our results, if generalizable, suggest that for students accustomed to writing on computer for only a year or two, such estimates of student writing abilities based on responses written by hand may be substantial underestimates of their abilities to write when using a computer.

This suggests that we should exercise considerable caution in making inferences about student abilities based on paper-and-pencil/handwritten tests as students gain more familiarity with writing via computer. And more generally it suggests an important lesson about test validity. Validity of assessment needs to be considered not simply with respect to the content of instruction, but also with respect to the medium of instruction. As more and more students in schools and colleges do their work with spreadsheets and word processors, the traditional paper-and- pencil modes of assessment may fail to measure what they have learned.

We suspect that it will be some years before schools generally, much less large scale state, national or international assessment programs, develop the capacity to administer wide-ranging assessments via computer. In the meantime, we should be extremely cautious about drawing inferences about student abilities when the media of assessment do not parallel those of instruction and learning.

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EPAA Editorial Board

Critical Issues in Evaluating the Effectiveness of Technology

by
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We are far enough along in the technological revolution and its application to learning that it is time for systematic review and analysis of what works best.

U.S. Secretary of Education Richard W. Riley
National Conference on Educational Technology
Washington, D.C., July 12, 1999

The *Secretary's Conference on Educational Technology: Evaluating the Effectiveness of Technology* on July 12-13, 1999, in Washington, D.C., noted a shift in schools' focus on technology. Where once the emphasis was on building and implementing a technology infrastructure, today it is on evaluating the effectiveness of its use in schools and classrooms. Parents and teachers, school boards and administrators, governors and state legislatures, and Congress all want to know if the nation's investment in technology is providing a return in student achievement. Indeed, if resources are to be expended on technology, it is becoming a political, economic, and public policy necessity to demonstrate its vital effectiveness.

In his opening address, U.S. Secretary of Education Richard Riley remarked, "The primary reason for this conference is to gather information from all of the outstanding schools, districts, and states represented here-so that we can study it, share it, and learn from it. Just as important as learning what works, we must learn what does not work. We must not assume everything that employs technology is going to be successful. That is why evaluation is so important. And then we must use that evaluation to create positive change."

The conference drew on the insights and collective wisdom of its attendees, starting with an emphasis on state-level technology evaluations. Evaluators from West Virginia explained how they isolated the effects of their Basic Skills/Computer Education initiative. They found that the more access to technology students had and the more their teachers believed that technology could help and were trained to use the technology, the higher students scored on the Stanford 9 (11% of the total gain scores). Idaho attendees described a four-year study focused on eight specific goals by which to evaluate the impact of the state's technology investment. Significant results included statewide academic gains as measured by the Iowa Test of Basic Skills (ITBS) and the Test of Academic Proficiency (TAP) for 8th and 11th graders.

From there, the conference turned its spotlight on school practitioners who expressed the need for more formative evaluations than the summative evaluations described by state policymakers. Lively debates arose among teachers, district curriculum and technology coordinators, administrators, state curriculum and technology coordinators, state and national policymakers, and researchers in the evaluation of educational technology about ways of identifying and collecting technology evaluation data that is relevant at the local level but also useful for other stakeholders.

During what Dale Mann of Interactive, Inc., called, "this developmental moment," conference participants exchanged promising evaluation strategies and techniques and considered how to respond to the many voices demanding to know technology's effects on schooling. The following seven critical issues in evaluating the effectiveness of technology in education arose as a consequence of the interaction among stakeholders:

- The effectiveness of technology is embedded in the effectiveness of other school improvement efforts.
- Current practices for evaluating the impact of technology in education need broadening.
- Standardized test scores offer limited formative information with which to drive the development of a school's technology program. Most schools are looking for additional means for collecting useful data for this purpose.
- Schools must document and report their evaluation findings in ways that satisfy diverse stakeholders' need to know.
- In order for evaluation efforts to provide stakeholders with answers to their questions about the effectiveness of technology in education, everyone must agree on a common language and standards of practice for measuring how schools achieve that end.
- The role of teachers is crucial in evaluating the effectiveness of technology in schools, but the burden of proof is not solely theirs.
- Implementing an innovation in schools can result in practice running before policy. Some existing policies need to be "transformed" to match the new needs of schools using technology.

Critical Issue 1: The effectiveness of technology is embedded in the effectiveness of other school improvement efforts.

> *Linking technology with core instructional objectives is what makes good, effective use of technology. That's the message we need to communicate. It's a process-not a number.*
>
> Margaret Honey
> Center for Children and Technology

A school's vision of the education it strives to provide students contains many elements, of which technology is but one. Other elements in this vision include administrative procedures, curricula, classroom organization, teachers' pedagogical approaches, time and space designations, school-community partnerships, and logistical and social factors. Developing ways to isolate the effects of technology within a dynamic environment where so many elements work together is one of evaluation's most challenging issues.

Evaluators at the conference argued that social phenomena such as learning contain so many interacting factors that traditional experimental designs don't yield effective information. They support using evaluation designs that penetrate the effects of implementing technology at both individual, organizational, and sometimes even community levels. Evaluation designs of this type may be based on a system of learning benchmarks and other new forms of assessments that take the "localness" of evaluation into account.

The high-stake decisions linked to technology implementation pressure educators to demonstrate that technology makes a difference in student learning. Many educators fear that evaluation places their technology programs at risk if they cannot produce measurable results in a relatively short time. The message that needs to be conveyed about the effectiveness of technology is that implementation of any sort produces outcomes. These outcomes, however, will be different at different stages of implementation.

- At Mantua Elementary School in Virginia, technology is viewed not as an end in itself, but rather as a tool that augments the following four pillars of the Basic School, which are (1) the School as Community (bringing into focus how people relate to one another and work cooperatively to solve problems); (2) a Curriculum with Coherence (bringing an interdisciplinary approach to the acquisition of knowledge); (3) a Climate for Learning (providing the physical and motivational factors necessary for effective teaching and learning); and (4) a Commitment to Character (emphasizing how the school experience shapes the ethical and moral lives of children). The school community members use technology to simplify, facilitate, and enhance individualized and social learning processes within its interdisciplinary curriculum. Teachers are seen as leaders, facilitators, and mentors, well grounded in technology implementation strategies and well trained in the use of the most current computing equipment and software applications. Children exposed to interdisciplinary units of study use technology as a tool to become literate, cooperative, problem-solving, self-motivated learners and that is what Mantua is all about. What most distinguishes education at Mantua Elementary is that its students are not passive recipients of knowledge, but rather, active participants in the full educational process.
- A technology-rich environment can support initiatives focused on improving learning outcomes as shown in Union City, New Jersey. The district framed its technology evaluation in conjunction with evaluation of school reforms such as students' development of literacy, higher-order thinking and collaboration skills. With district funds and funds from Bell Atlantic and the National Science Foundation, technology became a key catalyst for school improvements that led to measurable academic achievements. But, as one of the most impoverished urban communities in the United States, Union City faced an uphill battle against state takeover with more than a plan to implement technology. Technology was just one of eight key reform strategies integral to the district's reported success in making school improvements.

Critical Issue 2: Current practices for evaluating the impact of technology in education need broadening.

> *To a certain extent, we are living out the decisions reflected in previous evaluation methods, which constrain our thinking about the purpose and effectiveness of technology in education.*
>
> Walter Heinecke
> Curry School of Education at the University of Virginia

The issue that confronts schools is broader than technology. It is about learning and the need to find new ways to identify and measure the skills and knowledge that students gain from using technology. It is about stakeholders' needs for information beyond self-report analyses and traditional standardized testing. It is about building the capacity of teachers to evaluate technology resources and to align their uses with the learning goals and content standards of the curriculum. It is about evaluating technology implementation efforts, curriculum integration methods, and learning processes in order to make sound decisions for continual improvement. Ultimately, the issue is about involving the key stakeholders, identifying appropriate measurable indicators, and developing reliable instruments that will yield insightful and valid information about what makes educational technology effective.

The multimedia and networked capacities of the technology infrastructure are radically altering the face of technology-related practices in schools. However, the same rich diversity of technological tools that has created new learning opportunities for students has complicated the standardization of technology assessment. The fact that technology tools have undergone rapid cycles of innovation, causing constant change in the types of evaluation questions that need to be asked, compounds the difficulty even more. Educators, evaluators, and developers of measurement instruments struggle to keep current with the rush of information needs having to do with technology's effectiveness.

In order to understand changing evaluation practices, stakeholders from the policy level on down to the home, need information on how using technology changes teaching and learning, its organizational impact, and the outcomes that can be reasonably expected at different stages of technology's implementation. In short, the challenge facing educators and evaluators is to compile enough evaluation data to substantiate and articulate technology's place in student and teacher learning.

- Many schools at the conference reported that they do use standardized tests as a part of their technology assessment program, but they also look at other outcomes. Educators in the Cherry Creek School District in Colorado, for instance, are using methods they call "far from refined." They evaluate progress based on district goals such as developing students' higher- order thinking skills, promoting collaboration among students working on projects, and honing the research skills of students around real-world topics. Instead of conducting quantitative research, they rely on best practices uncovered by currently published research to guide their technology implementation. The district's philosophy regarding evaluation is that isolating technology as the cause of achievement, productivity, or change is impossible. Therefore, they evaluate systemically: looking at SAT and ITBS scores related to programs in which technology is used; analyzing results from their Technology Integration/Student Achievement Specialist Survey; using the National Educational Technology Standards to develop ways of measuring student progress in technology foundational skills-to name a few of their multiple measures.
- Technology "ubiquity" in supporting other programs has convinced skeptics of its value. Schools at the conference suggested that were it not for the access to people, resources, and ideas that technology provides, school programs, from student peer-mentoring and summer enrichment to teacher professional development, would be seriously crippled.

Critical Issue 3: Standardized test scores offer limited formative information with which to drive the development of a school's technology program. Most schools are looking for additional means for collecting useful data for this purpose.

Who gave legislators reading and math test score to begin with? We did. We need to give them other measures, tell them how technology works, and help them see the results.

David Dwyer
On-Track Learning, Inc.

Standardized tests scores have become the accepted measure with which policymakers and the public gauge the benefits of educational investments. But educators and evaluation researchers argue that these scores say little about how to improve technology's effectiveness in schools. For this, they need information from formative evaluation.

Formative evaluation tells what technology applications work, under what conditions, and with which students. It supplies information on how technology affects student attitudes toward learning. It can show the impact of technology on promoting collaboration among diverse learners. It can track technology literacy skills development and indicate the impact of technology access. Formative evaluation can tell teachers about their students' progress toward developing the skills to access, explore, and integrate information; think at high levels; and design, experiment, and model complex phenomena.

Formative evaluation also yields information on the effectiveness of professional development activities, the adequacy of school management systems, and other issues having to do with building the school technology infrastructure.

The good news is that schools have access to more information on these questions than they might think. Evidence of technology effectiveness may lie in fewer disciplinary referrals, students' completing more complex homework assignments, a new robustness in student performances, students taking more difficult electives or requesting particular teachers and courses, increases in requests for equipment and technical assistance, declines in special education placements, lower drop-out rates, rises in college applications and acceptances, increases in student job offers, and more parent participation.

Other information collected through simple observations and questionnaires is formative as well. What technologies do teachers and students use and why? What is their attitude toward them? How has technology changed how teachers teach? How has it affected students' engagement with learning materials? Even the use of physical space, such as the rearrangement of study carrels in spaces where students can engage in learning with their peers, for example, can symbolize changes brought on by the use of technology.

The problem is not so much the lack of data. The controversy revolves around accountability measures that ask the right evaluation questions; identify appropriate data sources; systemically capture the data; and analyze, interpret, and report the data in its appropriate context.

- An educator from East Brunswick Public Schools in New Jersey maintained that of all the ways to evaluate technology integration, including hiring external consultants to conduct an evaluation, "the easiest to look at is standardized test scores." The most compelling evidence, however, is in what the district calls "secondary indicators." According to one of these indicators, when technology was integrated into a ninth-grade science curriculum, enrollment in chemistry classes swelled by nearly 500 percent, with overall enrollment in science courses growing by 17 percent.
- Other educators at the conference reported discovering innovative indicators with which to evaluate technology's effectiveness:
  - High school humanities teachers in Oswego, New York, noted more varied citations in student papers after students began doing their research on the World Wide Web.

- The technology director in Montgomery, Alabama, observed that teachers put more detail and illustrative resources into their lesson plans than they used to.
- Educators in Iowa used Bloom's taxonomy of cognitive learning as a guide to observing technology-integrated learning units. They found that technology-integrated learning reached higher in Bloom's hierarchy than nontechnology integrated learning.
- A count in several districts showed that interdisciplinary instruction was more prevalent in technology-supported instruction.
- A technology coordinator from Anderson County Schools, Tennessee, summed up technology's effectiveness this way: "I know there is great impact because if the file server drops, teachers want to call the buses and go home."

- When test scores in Blackfoot School District, Idaho, revealed that students who used technology in their coursework scored 15 percent higher than those who did not use technology, no one in the community questioned technology's role or the capital investments that the district had made. Yet, when officials couldn't pinpoint a more exact effect of technology on student learning, they knew that their evaluation of technology effectiveness had to go deeper. They analyzed each piece of their technology system, including the role of learning benchmarks in content areas and grade levels, the usefulness of professional development activities, the unique effects of particular software, and the nature and goal of instructional activities.
- Reporting students' achievement of core competencies on network technology has provoked new interest in school improvement in several communities. In almost every case, posting these competencies sparked districtwide debate about the relevance of present standards. These dialogues drove districts' examination of student achievement deeper than ever before, resulting in teachers being better informed and more committed to addressing agreed-upon competencies.

Critical Issue 4: Schools must document and report their evaluation findings in ways that satisfy diverse stakeholders' need to know.

> *We cannot survive on the random story anymore.*
> Linda Roberts
> Office of Educational Technology at the U.S. Department of Education

Interest in the effectiveness of technology is at an all time high. Parents want to know if children are developing a sound content base and thinking skills, and if they are going to be capable of lifelong learning in a fast-paced technological society. Teachers want to know if technology tools will help facilitate what they want to happen in the classroom. Administrators want to know if professional development activities are improving the way teachers use technology to teach. Funders, policymakers, and taxpayers want to know if technology is sufficiently promising to continue investing in it. Documenting and reporting evaluation data to meet these diverse stakeholders' need-to-know presents educational evaluators with a daunting series of challenges.

The difference in the data needs of policymakers and educators is particularly acute. While policymakers want to see data on the isolated effects of technology, educators need information that is tied to systemic practices. Policymakers tend to value summative reports documenting student achievement while teachers and administrators value formative reports documenting implementation outcomes in order to make sound decisions about their technology plans. Many kinds of data are important, but each fails to satisfy the other. The best hope of closing this gap lies in helping all stakeholders to see (1) the importance of technology as an effective component of the educational system, (2) how technology is and isn't capable of making a difference in curriculum and instruction, and 3) how innovative practices of teaching and learning with technology require multiple measures in order to verify its impact.

Comparative language speaks loudly in this regard. It is useful to show technology's effects in a tangible way by, for example, comparing the instructional practices and learning opportunities that students have with technology to instruction without technology. Open dialogue and an understanding of mutual expectations for performance throughout the technology implementation process can resolve much of what differentiates stakeholders' interests in technology outcomes. What information do these groups need? What type and how much documentation do they require? What standards of documentation are most useful to different stakeholders? These are useful questions to consider.

Finally, communicating about evaluation requires "speaking to" the stakeholder audience. What is the audience's level of technology sophistication? How knowledgeable is the audience about evaluation terms and procedures? Speaking the language of the audience-by converting effect sizes into months of academic gain, for example-influences the way people think about technology and their support for it. The technology infrastructure, itself, can be a useful tool for capturing, interpreting, and reporting data from multiple measures into understandable terms for a variety of stakeholder audiences.

- When schools in the Juneau, Alaska, instituted electronic report cards to inform parents how and in what ways their children were meeting core content standards, communications between teachers and parents surged. A middle school teacher described this new type of access to parents as "empowering" her partnership with parents to guide their children's learning.
- Educators at the conference considered parents one of their most important audiences. Once parents understood the value of technology, they became advocates. Parents, in fact, were often instrumental in moving technology into the classroom. The question that lingers is how to spread the message from parents to legislators. Some part of the answer, conference goers maintained, lies in encouraging parents to bear the message to policymaking bodies.
- Conferees voiced concerns about the media's portrayal of technology programs in many of the nation's schools and districts. While applauding the media's role in informing the public about technology, educators charged that its interest in profiling technology growth and use "in one chart on one page" shortchanges the diversity of outcomes that technology produces. Participants suggested that the best way to encourage more comprehensive portrayals of school technology programs in the media is to link technology outcomes to goals that are deeply embedded in the mission and culture of the school.

Critical Issue 5: In order for evaluation efforts to provide stakeholders with answers to their questions about the effectiveness of technology in education, everyone must agree on a common language and standards of practice for measuring how schools achieve that end.

You have to show people the qualitative difference in what kids can actually do.

Eva Baker
National Center for Research on Evaluation, Standards and Student Testing at the University of California Los Angeles

Dialog among stakeholders plays a central role in evaluation efforts. Stakeholders must be attuned to common goals for the uses of technology, information needs, cultural terms, and methods for measuring outcomes. They must have consensus around roles and a clear vision of where they are going and the steps they need to take to get there.

State-level consortia, made up of representatives from many stakeholder groups, can help develop guidelines that address schools' questions such as: What are important technology-induced indicators in our state and what instruments are available to measure these indicators? Where are the gaps in evaluation needs and measurement tools within our school communities? How can district educators and university researchers collaborate to develop evaluation instruments that will measure technology's effectiveness in our schools?

Educators have known for a long time that technology can help students learn basic skills. But the tools that measure basic skills don't evaluate how technology supports students in developing capacities to think creatively and critically and vice versa. There is a need to develop additional evaluation tools that can help measure whether students are learning the "new basics" such as computer literacy, collaborative teamwork skills, and lifelong learning abilities.

Left to themselves, schools have little time to develop and test such evaluation tools. While the successful evaluation of a school's technology does not necessarily require that researchers and evaluators be on the scene, seeking such expertise can be helpful, especially in evaluations that encompass several buildings or districts. Many universities offer technology evaluation expertise. In addition, regional educational laboratories and technology education consortia allocate many of their resources to helping schools address evaluation issues. Other for-profit and not-for-profit organizations can also be helpful. Still, it is difficult for schools to identify what assistance is available. The field is ripe for developing scalable approaches, tools, and strategies for evaluating the effectiveness of educational technologies.

The most useful tools yield information that is specific to the given student population and that allows teachers to track students' progress over time. Tools also need to measure those aspects and outcomes of learning that would otherwise be unattainable without the use of technology. Evaluation that demonstrates what students can do with technology that they couldn't do before access to the technology shows impact. For example, performance measures-observations of what students do and where they go on the Internet and how students collaborate with each other-help teachers track the impact of technology on student learning. Other measures that tap into education's broader curriculum aims include projects, essays, and extended performances.

- Several school district representatives reported replacing student technology competency requirements with technology/content area integration standards as a basis for benchmarking grade-level technology integration. Their rationale was that this shift emphasizes technology's supportive role in teaching and learning rather than making technology use an end in itself. These educators believe that indicators articulating the components of a model instructional unit in fourth-grade science, for example, are more useful than technology competencies students should demonstrate at the fourth-grade level.
- Early in the conference, it became clear that technology has spurred new terms and/or word meanings in our vocabulary. The term "engaged learning," for instance, had a very different meaning for participants from Chicago Public Schools than it did for educators in Cherokee County School District in Alabama. Similarly, when one participant referred to "performance standards," educators from New Hampshire's Campton School District envisioned a very different

set of standards than did their colleagues from the Okaloosa County School District in Florida. These exchanges illustrated the need to come to consensus on the terms and language of the evaluation process. Terms such as "technology integration," "benchmark," "core competency," "alternative assessment," and even "evaluation" and "student achievement" elicit different meanings from a range of educators and, unless they are made clear, can undermine evaluation efforts.

Critical Issue 6: The role of the teacher is crucial in evaluating the effectiveness of technology in schools, but the burden of proof is not solely theirs. *Evaluation is part of a reflective process. The more reflective we are, the more likely we are to improve our practice.*

Charol Shakeshaft
Hofstra University

Technology has revolutionalized what teachers do. It has added new breadth and depth to instruction. This, in turn, has transformed the role of the classroom teacher. In reformed educational settings, teachers guide students in using telecommunications to interact with astronauts in space, searching the Internet for up-to-the-minute information, and programming technology systems to help solve local or global problems.

The countless hours teachers spend observing and interacting with students makes teachers a rich source of data about the impact technology has on student learning. Teachers are the first to recognize increases in students' self-esteem and confidence, enhanced content area understanding, and more informed and empathic responses to world events as a result of using technology. This new role for teachers underscores the need for high-quality professional development in the use of technology and in determining what and how students learn best with technology tools.

What teachers know about their students and about technology determines their competence in day-to day classroom decision-making. Good teachers evaluate their students and make decisions about how technology can boost their learning on a daily basis. Do students have access to the appropriate technology resources and tools? Are students using the technology efficiently? What kinds of learning tasks will challenge students' creative and critical thinking? In this new technology environment where there is not one instructional strategy but many, teachers need to know how to manage interactive group dynamics as well as technological systems.

Professional development in schools that have implemented and evaluated educational technologies successfully helps teachers link effective uses of technology to impacts on student learning. Evidence of technology literacy, faculty meeting agendas, lesson plans, and classroom observations are all ways to determine a teacher's grasp of technology as a learning tool. The most useful program evaluation is one in which a strong formative element examines the connection between instructional practice, technology uses, and learning outcomes.

Teachers are integral to the process of evaluating technology initiatives. They can act as partners with researchers to identify the sometimes very subtle impacts associated with technology uses. Teachers can also play key roles in measuring and documenting changes in student learning as they occur. Some of the best results in evaluating technology come from schools recognizing and harnessing the expertise teachers have in identifying technology-induced learning outcomes.

Teachers who have learned to use technology effectively in the classroom are convincing their colleagues of technology's potential. Teachers training teachers to evaluate the usefulness of technology in the classroom remains a potent professional development strategy.

- Evaluators must learn to trust teachers' ability to determine and describe technology's "ripple" effects, Margaret Honey, director of the Center for Children and Technology, explained during the conference. Success in studying school technology programs, according to Dr. Honey, often hinges on teachers contributing to the development of research questions and sharing ideas on how to record key indicators of effectiveness.
- Lennox School District in southern California builds teachers' capacity to evaluate student learning with technology by having teachers collaboratively score students' work. Examining student products together builds consensus among teachers on the curriculum's core goals and the types of assessments that measure the achievement of those goals.
- The nature of the questions that teachers ask their technology coordinators are data for evaluation. Their questions can indicate a school's position along the continuum of technology implementation. A technology coordinator from Helena, Montana, observed that when schools first deployed technology, teachers' questions centered on getting the hardware to work. Only a couple of years later, these same teachers' questions revolved around content and accessing resources through the network.

Critical Issue 7: Implementing an innovation in schools can result in practice running before policy. Some existing policies need to be "transformed" to match the new needs of schools using technology.

> *Our goal should be first, to understand the conditions of pro-social technology use and second to employ that understanding for learning improvement. Both require more penetrating analysis than has heretofore been the standard.*
>
> Dale Mann
> Interactive, Inc.

Today's classrooms are expected to be technologically up to date. The same should be true for the policies that govern technology uses. When federal, state, or local district or building level policies do not keep up with classroom practices, innovative and effective practices can grind to a halt. To this end, educators have a leadership role in using evaluation information to shape the conversation around the kinds of policies that are most supportive in validating best practices that enhance the work of the school community.

Policy issues rise to the surface around data. Who should have access to what data in the student information system? In theory, information about a student's family situation, for example, can help teachers understand and respond to student learning and behavioral problems. With today's information technology networks, accessing all kinds of personal family information in student files is possible-but what are the ethical policy implications for doing so?

Still another example of how the lack of policies can slow down reform has to do with the equitable allocation of computers and other technology resources. Does a school distribute computers to students who need them the most, or to those students whose teachers show the most computer proficiency? What is a school's responsibility for out-of-school computer access? How are scarce technology lab resources scheduled for use by the school community during and after school hours? Does a school have a policy governing the use of its technology to address adult technology literacy needs?

Many school communities have recognized the need to create and enforce Internet usage policies, for instance, but what other less obvious technology-related policies are required to support and govern the best practices associated with implementing technology innovations into the school system? Local educators have the experience to help shape such questions and define successful practice for state and federal policymakers. These policymakers can then respond by developing policies that support the effective use of technology at the local level on a systemic basis. An important part of policy reform is to give policymakers a common language and data with which to speak to their constituents so that support for effective uses of technology will be widespread throughout the community.

- Kayenta Unified School District (KUSD) is a small rural Navajo community located in an isolated region in the northeastern corner of Arizona, near the magnificent Monument Valley. This school district serves 2,600 students from Kayenta and several other smaller, more rural communities. The nearest public library is 100 miles away, while the nearest museums, bookstores, and universities are 150 miles. This isolation has provided the motivation to use technology to assist in increasing literacy, while permitting students to sustain critical elements of the rich traditional life of generations of Diné. After ten years of hard work building their technology infrastructure, KUSD presently has all six schools and administrative buildings, and all classrooms, offices, and administrators connected to an Internet/intranet e-mail system. Determining ways to complement traditional instruction and community values with the global access provided by the Internet has been a compelling policy, as well as curricular, challenge faced by Kayenta and other rural isolated school districts. Kayenta distance learning policies opened the school community to the outside world in many ways.
- More and more as teachers and parents gain access to e-mail communications and evaluation data via the Internet, schools are finding it difficult to maintain current information policies governing information access. A case in point is the use of e-mail for parent-teacher communication. While in theory, frequent communications between parents and teachers is a positive move forward, practitioners pointed out that having to respond to frequent requests from parents about their children's schoolwork tears them away from instructional planning time. This raises policy questions about teachers' obligations to respond to individualized e-e-mail requests from parents.
- Educators at the conference demonstrated their broadened view of outcomes by recounting stories of timely access, attitudinal change, and increased motivation. Most initiatives in their early stages feature such stories. Their telling is an important step in shaping realistic public and legislative expectations for technology evaluation and supportive policies.

What's Next?

Schools that have partnered with other schools, universities, and educational service agencies to collaborate on technology planning, implementation, and research show compelling and productive applications of technology. Now comes the call for rigorous technology evaluation designs that are innovative and relevant to showing its impact.

Researchers and educators are finding ways to partner in evaluating the technology initiatives that they've instituted. Such partnerships are revolving around many different purposes. Universities are partnering with schools to construct the next generation of evaluation tools and processes. State and federal governments are beginning to reserve grant monies for evaluation activities in order to identify and disseminate information about technology practices that work and that may benefit schools in other contexts. Policies are beginning to be discussed that will support these and other innovative practices.

The *Secretary's Conference on Educational Technology: Evaluating the Effectiveness of Technology* took a step forward in bringing together federal, state, and local evaluators with school practitioners to understand the many puzzle pieces involved in evaluating the effectiveness of technology in education. In many respects, the discussions and presentations at the conference raised more questions than they answered. In other respects, the diversity of research and best practices shared by participants represents the "state-of-the-field" in evaluating the effectiveness of technology in schools. The need to evaluate the effectiveness of technology in schools fuels a vast potential for collaboration among schools, universities, research organizations, businesses, and community groups.

A multimedia CD-ROM will be available for those wishing to further delve into these critical issues raised at the conference (see the order form). In addition to providing examples of and expert commentary on spotlight school evaluation practices, it also contains templates for guiding school leaders' thinking about designing an evaluation plan. The U.S. Department of Education has launched a conference Web site at http://www.ed.gov/Technology/TechConf/1999/. Check it for the conference proceedings, announcements, and online events. In addition, follow-up regional conferences are being planned for the millennium year to focus more in-depth on the impact technology has on schooling and the evaluation needs to show the nature of those impacts.

Conference Agenda | Spotlight Schools | Spotlight School Contacts | Conference White Papers | Featured Speakers | Acknowledgements | Conference Summary

UP Return to Conference Main Page

ED HOME

Page last updated on November 30, 1999 by [eid]

- Conference Summary
- Conference Agenda
- Spotlight Schools
- Spotlight School Contacts
- Conference White Papers
- Featured Speakers
- Acknowledgements

The Secretary's Conference on Educational Technology

★ RICHARD W. RILEY,
U.S. Secretary of Education

★ PAULO RENATO SOUZA,
Minister of Education and Sports (Brazil)

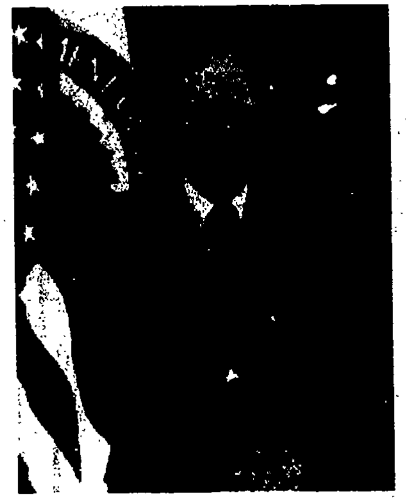
Conference Agenda | Spotlight Schools | Spotlight School Contacts | Conference White Papers | Featured Speakers | Acknowledgements

Return to Conference Main Page

ED.GOV

Page last updated on November 30, 1999 by [eid]

The Secretary's Conference on Educational Te,hnology



RICHARD W. RILEY

U. S. SECRETARY OF EDUCATION

On July 12, Secretary Riley delivered a speech at the National Conference on Education Technology, Washington, DC.

The *Christian Science Monitor* says that many Americans regard Dick Riley as "one of the great statesmen of education in this century." David Broder, columnist for *The Washington Post*, has called him one of the "most decent and honorable people in public life." And when Riley was governor of South Carolina, he was so popular that the people amended their constitution to enable him to run for a second term.

Wherever he goes, Richard Wilson Riley--U. S. Secretary of Education and grandfather of ten--wins respect for his integrity, principled leadership, commitment to children, and passion for education.

President Clinton chose Dick Riley to be Secretary in December 1992 after Riley won national recognition for his highly successful effort to improve education in South Carolina. During the President's first term, Riley helped launch historic initiatives to raise academic standards; to improve instruction for the poor and disadvantaged; to expand grants and loan programs to help more Americans go to college; to prepare young people for the world of work; and to improve teaching. He also helped to create the Partnership for Family Involvement in Education, which today includes over 4,000 groups.

Riley gets things done by reaching out to all citizens. He prefers partnership to partisanship. His quiet, self-effacing style "can drive impatient, assertive young Washington movers and shakers crazy," the *National Journal* has written. "He doesn't grab headlines or clamor for credit... But, inevitably, Riley reaches his goal."

Riley's efforts were so successful that President Clinton asked him to stay on in his second term to lead the President's national crusade for excellence in education. Riley and the President agree that education must be America's number one priority in the years ahead. Already in the second term, Riley has helped win an historic ruling by the F.C.C. to give schools and libraries deep discounts for Internet access and telecommunications services and helped win major improvements in the Individuals with Disabilities Education Act.

Riley's goals now include helping all children to master the basics of reading and math; making schools safer; reducing class sizes in grades 1-3 by helping states and schools to hire 100,000 more good teachers; modernizing and building new schools to meet record-breaking student enrollments and to help students learn to use computers; and expanding after-school programs.

Dick Riley was born in Greenville County, S. C., on Jan. 2, 1933. He was graduated *cum laude* from Furman University in 1954 and served as an officer on a U. S. Navy minesweeper. In 1959, Riley received a law degree from the University of South Carolina. He was a state representative and state senator from 1963-1977 and was elected governor in 1978 and reelected in 1982. Riley is married to the former Ann Osteen Yarborough. They have four children.

Page last updated on July 20, 1999 by [eid]

- Conference Agenda
- Spotlight Schools
- Spotlight School Contacts
- Conference White Papers
- Featured Speakers
- Acknowledgements

The Secretary's Conference on Educational Technology

Minister of Brazil

PAULO RENATO SOUZA

Minister of Education and Sports

Minister of Education Homepage

Education:

Economics degree from the Federal University of Rio Grande do Sul. Master's Degree from University of Chile. Doctorate from State University of Campinas (UNICAMP).

Professional Experience:

Field of Education - Senior Professor at the Institute of Economics at the State University of Campinas. Lectured at the Federal University of Rio de Janeiro, the University of Chile, the Catholic University of Sao Paulo, and the Catholic University of Chile.

Research - Visiting researcher at the Ecole de Hautes Etudes en Sciences Sociales in Paris and the Institute for Advanced Study in Princeton, NJ.

Administrative Positions - Operations Manager and Vice President of the Inter-American Development Bank. In the 1980's, he was Rector at the State University of Campinas, Secretary of Education for the state of Sao Paulo, and President of the Data Analysis Division for the State of Sao Paulo. In the 1970's, he was an employment specialist at the United Nations and Deputy Director of the Regional Employment Program for Latin America and the Caribbean.

Implementation of the Brazil-USA Partnership in Education

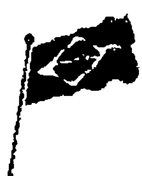
According to the *Report of the Summit of the Americas Working Group*, the development of the education in the region faces three key challenges: first, profound inequality in the availability of material means and qualified teachers, leading to education of substantially inferior quality for children who attend schools in rural or low-income areas; second, the relative isolation of schools, which severely hinders an exchange of experience among them and prevents integration into national systems; and third, the difficulty of harmonizing the various dimensions of educational processes, be they national and local or individual and collective.

In Brazil the percentage of schoolchildren who complete their basic education is still small. This is a challenge for policy makers and educational administrators.

In this context the use of new technologies in the classroom in conjuction with distance learning programs can potentially enhance the quality of education, extend the opportunities for access to education, and promote the adoption of attitudes that lead teachers and students to see learning as a lifelong process.

The introduction of new technologies cannot be confined to the acquisition of equipment, however. It is essential to allow enough time for the requisite change in the motivations and behavior of teachers and administrators.

To learn more visit the US/Brazil Learning Technologies Network.



Visit Brazil's web page.

Conference Agenda | Spotlight Schools | Spotlight School Contacts | Conference White Papers | Ministry of Brazil | Acknowledgements

Return to Conference Main Page

Page last updated on July 12, 1999 by [dls]

The Secretary's Conference on Educational Technology

Acknowledgements

Conference Agenda

Spotlight Schools

Spotlight School Contacts

Conference White Papers

Featured Speakers

Acknowledgements

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Gateway, Inc.

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Conference Agenda | Spotlight Schools | Spotlight School Contacts |Conference White Papers | Featured Speakers | Acknowledgements

Return to Conference Main Page

Page last updated on July 6, 1999 by [eid]

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